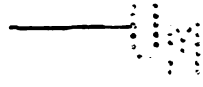
MODERN

ELECTRO PLATING.



The Principles Involved in Depositing Gold, Silver, Nickel, Copper, Brass and Other Metals, by means of Batteries or Dynamos; The Preparation and Management of Plating Baths, Chemicals Used, Etc.

BY J. H. VAN HORNE.

CHICAGO:
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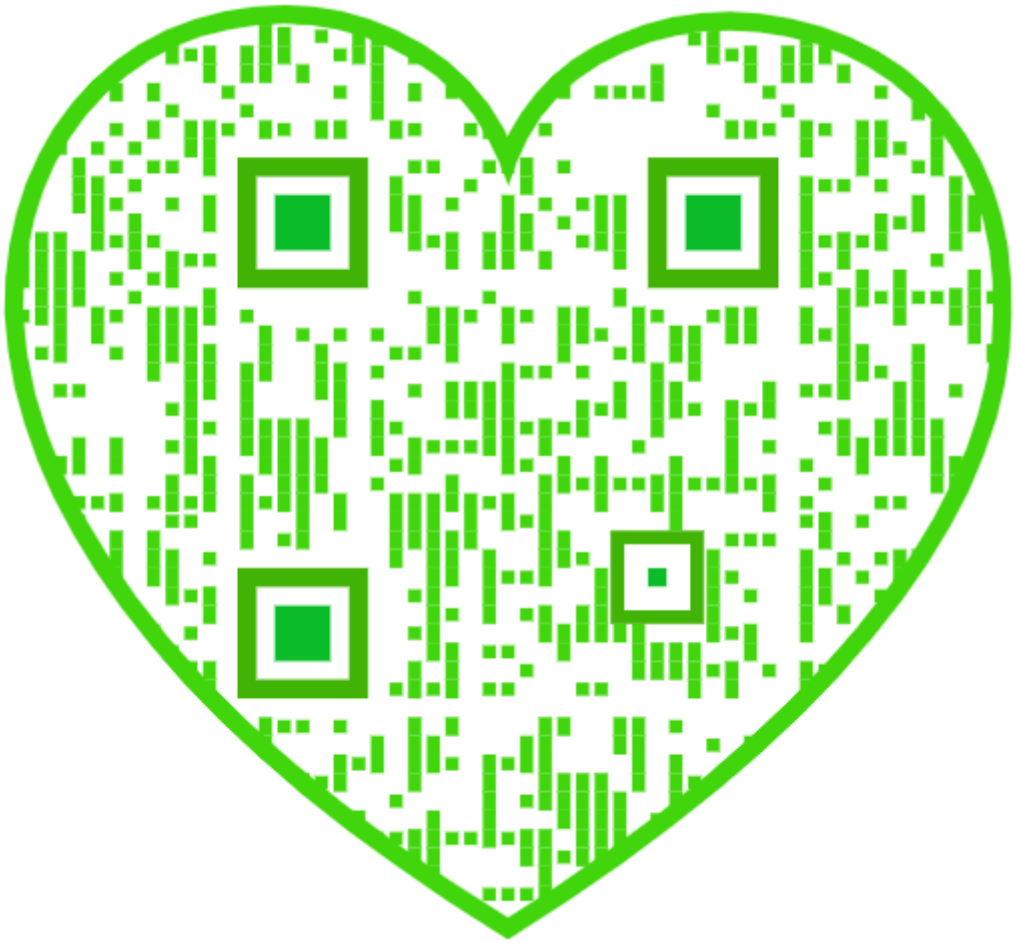

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INTRODUCTION.

This little work has been prepared chiefly to help out of his difficulties the plater in country towns, who has purchased a small outfit and begun operations without previous training in a plating establishment, where modern methods have been employed with a due regard for speed and economy in turning out the work. Hence it has been thought best to confine our remarks chiefly to the principles involved in the work, and to tell in a common sense way, how the work is done; what forces are employed; how they are handled, and how the various formulae may be made and varied to suit the conditions of the work, or to overcome the difficulties that may arise in continuous working of solutions.

It has seemed better to do this than to give a large number of formulae which, although they may be perfectly adapted to a special purpose, contain in themselves no real information, but have to be taken blindly, like a physician's prescription for a fever. It must not be forgotten that the chemistry of plating has undergone

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strict investigation in the last five years by thoroughly educated and competent men, who have found abundant opportunity for their labors in the many large plating works now used in connection with manufacturing establishments, where the finishing of the products is of the highest importance, and owing to the quantity of goods turned out any defect in the composition or management of the baths is of the highest importance. The labors of these chemists have been chiefly effective in eliminating from the formulae in common use those chemicals which, from their nature, were antagonistic to the chief ingredients, or which by their decomposition left detrimental or inert matter in the solutions. As an instance of this we may mention the substitution of chromic acid for bichromate of potash in battery fluids; the purchase and use of the carbonate of copper and zinc in brass solutions instead of compounding them in the old way from the sulphates, etc. In all cases the effects of the alterations have been to simplify and greatly improve the keeping and working qualities of the solutions, and in many cases the improvement has been very great. These new methods of making solutions have been industriously circulated by the dealers in plating apparatus and supplies, until now the chief source of trouble in plating has shifted from the plating to the polishing department, and

while the chief difficulty formerly lay in the solutions, nine out of ten cases of trouble now may be traced to the improper preparation of the work before it reaches the bath, or to careless and hasty finishing after it has left it. Therefore, it has seemed better to deal with the operations of plating in a general way, detailing the principles involved, and allowing the operator to make his own baths from general directions, rather than to follow the empirical methods formerly employed, which gave no hint of the source of any difficulty, and left the plater unable to help himself when trouble was encountered.

It will be readily seen from the above remarks that plating has been stripped of about all the mystery that formerly surrounded it, to the great chagrin and vexation of a certain class of workmen who formerly found an easy way of getting an income by the sale of certain very important and mysterious formulae, without which, they solemnly assured their intended victim, *good* plating could not be done. In fact, it is now generally recognized that good, durable plating depends chiefly upon the degree of care and skill employed in the application of well known methods of doing work, while the question of profit depends altogether upon the personal dexterity of those who do the work, and a rapid and skillful plater holds the same relation to his fellow

employes that a rapid and skillful machinist does in his trade.

With this explanation we think the reader will sufficiently grasp the scope and purpose of this work. It does not pretend to teach everything, but only to prove useful in aiding the workman to a general understanding of the subject which will enable him to consult other books intelligently, or to help himself where other guidance is not available.

The little pamphlet, "Practical Points on the Deposition of Metals," which was the first attempt to give practical information in a general way has been so warmly received that it encourages me to hope that more on the same subject will be appreciated by those who are desirious of acquiring skill in the art of plating.

J. H. VAN HORNE.

CHAPTER I.

THE MANAGEMENT OF BATTERIES.

The first requisite in attempting to do electroplating in a small way is to understand the battery and to select one that will give an electric current of the proper intensity and quantity for the required time, without too much care and attention on the part of the workman. Were he provided with measuring instruments, so that he could readily determine when his current was changing in quantity and power, the choice of a battery would not be of so much importance; but volt meters and ampere meters are too expensive to be possessed by the average man who does plating in a small way, and he is necessarily obliged to depend on theory in arranging his forces and judge of the results by the appearance of his work in the bath. Hence it is important that he should have an understanding of the nature of the action in the battery and be able to maintain the requisite conditions from the appearance of the battery itself.

Electricity.—Without attempting to give too close a definition, electricity may be defined as a force or energy which is the result of a displacement of the normal balance of forces between two elements connected with one another by a conducting medium. This difference in the balance of force is called the potential of its elements, and if two elements having different potentials are connected together and placed in a fluid which will produce chemical action upon one or both, the result will be a flowing of energy through the connection to the element having the lowest potential. This will be kept up as long as the chemical action continues and the connection between the two elements remains unbroken. It will be readily seen, that owing to the varying potentials of the different elements, the varying facility of the conductors used to connect them, and the varying intensity of chemical action in the solution employed, the electrical current will vary in strength (or voltage) in different batteries, and in quantity, according to the size of the elements and the freedom with which they are attacked by the solution.

Voltage is the measure of strength or intensity of the current and depends upon the difference of potentials of

the elements and the kind of chemical action between them. It is the same for the same combination, regardless of the size of the elements. Thus, a battery the size of a thimble has the same voltage as one the size of a door, if the elements and solution are the same. We have not the space to explain this at length, but will simply state that the volt is the recognized unit of the measurement of strength of electric currents.

The Ampere is the unit of measurement of the quantity of currents. Amperage depends on the size of the elements, and the available amperage depends on the size of the conductors and the freedom of action between the elements. Amperage is consumed by doing work, or by the heating of insufficient conductors, or by undue resistance in the battery, just as power is consumed in turning steel, or in running shafting, or overcoming the resistance caused by friction of boxes on a shaft that is run without oil. Strictly speaking, if the voltage or intensity of the current be sufficient to do the work required, then the amperage is the force used to do the work, and it is destroyed by that work and the chemical or electrical resistance, just as mechanical power is consumed in running a lathe or doing any other work. From this, it follows, that in order to operate

economically, extreme care should be taken that the connections are large enough to carry the current easily; that the solutions be kept in perfect order, both in the battery and the plating vat; and that all joints be kept bright and firm so as to insure perfect contact and offer no resistance to the passage of the current.

The current always flows from the element having the highest potential (called the + or positive pole) along the wire and through the solution in the plating vat, to the other wire, and thence to the negative pole, carrying with it in passing through the solution, particles of metal from the anode and depositing them on the article to be electroplated (called the cathode); hence care should be taken to *always* get the cathode affixed to the *negative* (—) pole of the battery, in order that it may receive the deposit.

Electrical Resistance is that property of conductors (wires, solutions, objects, etc.) by which they tend to reduce the intensity of a current passing through them. The practical unit of resistance is the ohm. The number of amperes of current flowing through a circuit is equal to the number of volts of electro motive force, divided by the number of ohms of resistance in the entire circuit, that is from positive pole clear through

wires, solution and battery, back to the starting point. Thus it will be seen that if the resistance be greater than the voltage of one cell will overcome, no current will flow, and the voltage must be increased to such an amount as will allow the desired quantity of current to pass. This is done by coupling cells in various ways which will be explained at length further on.

The resistance of a conducting wire is directly proportional to its length, and inversely proportional to the square of its diameter; hence it follows that the short and large wires cause less loss of current than smaller and longer ones.

In all batteries the resistance increases with the distance between the elements, and decreases when the immersed surfaces are increased. The resistance is also increased by the bubbles of hydrogen liberated at the positive pole sticking to it in great numbers. Hydrogen is a non-conductor and prevents the action of the solution on the metal. When this takes place to such an extent as to stop chemical action altogether, no current will pass and the battery is said to be polarized.

These remarks are intended to aid in the intelligent selection of batteries, etc., those who, having to deal with such apparatus, yet have never had the opportunity to study an electrical treatise. We are often asked:

What is the best battery? We can only answer: There is no best battery; that is, no battery is suited to all kinds of work. That which is best in one case may be worst in another. The suitability of a battery for any special purpose depends on what is called its constants, i. e., electro-motive force and internal resistance. In order to be really perfect a battery should fulfill the following conditions.

1. Its electro-motive force should be high and constant.

2. Its internal resistance should be small.

3. It should give a constant current and must therefore be free from polarization, and not liable to rapid exhaustion, requiring frequent renewal of material.

4. It should consume no material when the circuit is open.

5. It should be cheap and of durable materials.

6. It should be manageable and, if possible, should not emit corrosive fumes.

No single battery fulfills all these conditions, however, and, as we have already intimated, some batteries are better for one purpose and some for another. Thus, for telegraphing through a long line of wire, a considerable internal resistance is of no great consequence, as it is but a small fraction of the total resistance in circuit.

For electric gas lighting or other low resistance circuits, on the other hand, much internal resistance would be, if not absolutely fatal, certainly a positive disadvantage. The most reliable batteries for electroplating work are the Daniell, Gravity, Bunsen, Smee and Carbon, which, we will accordingly describe in their order.

The Daniell, Fig. 1, consists of a glass or stoneware jar, containing a cylinder of copper surrounding a porous clay cup, in which stands a cylinder of zinc. At the upper part of the copper sheet is a pocket of perforated copper, which is filled with crystals of sulphate of copper. The object of the pocket is simply to hold the sulphate up to the top of the solution, so that it will dissolve more readily, and any other method would do as well. In charging this battery, the glass vessel and the porous cup are filled with water, and crystals of sulphate of copper are put in the pocket. If wanted for immediate use, a small quantity of sulphate of zinc may be dissolved in water and added to the

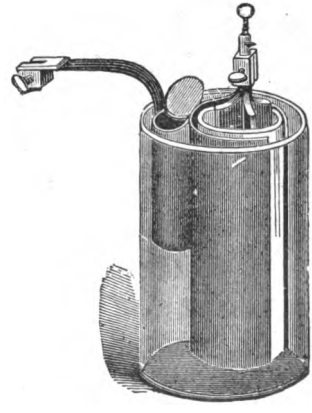

Fig. 1.

porous cup; if not wanted immediately, the battery may be short circuited by connecting the zinc and copper elements by a piece of copper wire, and it will attain its full strength in ten or twelve hours. A little sulphuric acid dropped in the porous cup will answer just as well, if sulphate of zinc is not on hand. The chemical action of this battery is as follows: The zinc decomposes the water, forming oxide of zinc and liberating the hydrogen. The oxide of zinc attacks the sulphate of copper, depriving it of the acid, which forms sulphate of zinc, and leaving it as oxide of copper; the oxide of copper is thereupon attacked by the hydrogen, which combines with the oxygen and forms water, while the metallic copper falls to the bottom as a fine powder. It will thus be seen that action is simple and continuous, no fumes are given off, and all that is required to maintain the action is a regular supply of copper sulphate to keep the fluid in the outer jar near the point of saturation. The most prominent fault of this battery is the tendency of the copper to fill the pores of the cup, and thus decrease the action of the battery. It can be partially prevented by coating the bottom and about a quarter of an inch of the sides of the porous cup with wax, and brushing off the deposit of copper on the cup as fast as it is formed. The battery should not be

allowed to stand on open circuit without the zinc element being removed, and the sulphate of zinc solution in the cup should not be heavier than 25° B. nor lighter than 15° B. If these precautions are observed, the battery should give a constant and free current as long as any zinc remains. Its electro-motive force is about 1.07 volt, and a gallon cell will give about one-half ampere, when in good order, on a short circuit. Its internal resistance varies, but should not be allowed to exceed three to five ohms.

The Gravity Battery. In consequence of the trouble caused by the precipitation of the copper on the porous cell in the Daniell battery, Cromwell F. Varley, in 1854, while experimenting, found that the difference in specific gravity between solutions of sulphate of copper and sulphate of zinc was sufficient in itself to entirely separate them, the copper solution lying at the bottom of the cell, and the zinc solution remaining superposed upon it. He accordingly dispensed with the porous cup, placed his copper element at the bottom, and the zinc near the top of a glass jar, and thus originated the gravity battery of today. It is the simplest, most reliable and constant form known, and has displaced all others for closed circuit work, requiring a low voltage,

such as telegraphing, etc. Its voltage, when first set up, is 1.07, running down under constant work to .90, and a gallon cell will give one half ampere on short circuit. The form of cell shown in Fig. 2 is known as the "crowfoot," on account of the manner in which the zinc (positive) element is spread out, to expose a large surface of zinc to the solution. It is the form used for telegraphing, and, therefore, can be readily obtained anywhere. Of course, other forms, shapes and sizes can be made at the option of the workman. To set up this battery, the copper strip, being unfolded so as to form a cross, is placed at the bottom of a jar, the zinc is suspended from the top as shown, and clean water, containing one-tenth of a saturated solution of sulphate of zinc is added, until it nearly touches the zinc. Sulphate of copper crystals are then added until, if the battery is meant to be continually used, they nearly cover the top of the copper strip. If the battery is not intended for continual use, it will be found more advantageous to use but a few ounces of sulphate of copper, as the more concentrated the solution, the greater is the tendency to local action. The

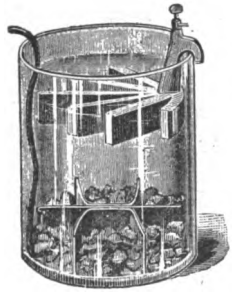

Fig. 2.

sulphate of zinc may be dispensed with if the battery is not required for immediate use; in this case, the latter should be short circuited, and left so for several days. The need of blue vitriol will be indicated by the discoloration of the lower stratum of the liquid. It is best to keep the line marking the two solutions about half way between the zinc and copper. Should the sulphate of zinc become too concentrated, a portion of it should be removed by means of a syringe or cup, and its place supplied by water. To determine when this is necessary, a hydrometer may be used. Below 15° the solution is too weak; above 25° it is too strong, and should be diluted. If the battery is taken care of from month to month, it should not require a thorough cleaning more than once a year. When this is done the deposits formed upon the surface of the zinc should be scraped off, the jars washed and the liquids renewed as in the beginning.

If, however, the batteries are in constant use, care must be taken to keep the zincs clean and the solutions as indicated above. If the sulphate of zinc is allowed to become saturated, it will crystalize on the zinc and on the edge of the jar, gradually creeping over the edge. This should be wiped off with a damp cloth and a little oil or fat smeared over the top of the jar to prevent

creeping. The jars should not be disturbed, as this would cause the two solutions to mix, and they should be kept in a dry, even temperature (60° to 80° F.). Freezing would stop the action of the battery.

The Bunsen, or Carbon Battery, Fig. 3, consists of a glass jar containing a hollow zinc cylinder, slit on one side to allow a free circulation of the solution; within this stands a porous cup containing a bar of carbon. To charge this battery, the amalgamated zinc is placed in the glass jar, the porous jar in the center of the zinc cylinder and the carbon in the porous jar. In the outer jar is sulphuric acid, diluted with twelve times its weight of water, and in the porous jar electropoion fluid. (See *Electropoion Fluid.*)

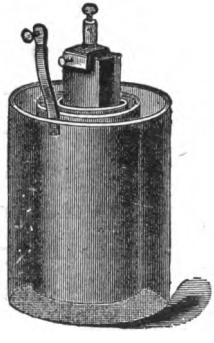

Fig 3.

The voltage of this battery is 2.028; its amperage cannot be given, as it depends largely upon the care which is given the battery, the size of the cell and the condition of the porous cups, which vary greatly in porosity and conducting power. It emits fumes of hydrogen and sulphurous acid if not in good condition, and should not be used in the same room with fine tools

or metal work that is liable to injury. It soon runs down, requiring recharging every day when in constant use, but it is simple to handle when understood, and is generally furnished in small outfits for nickel plating, etc., on account of its high voltage and the quantity of current given off when in good order. The zincs must be kept well amalgamated or they will polarize very rapidly and destroy the current; care should also be taken that no sediment be allowed to accumulate in the porous cup and fill its pores, thus stopping the action. It is more expensive to run than the gravity, as the zincs are eaten by the acid much faster, especially if not kept well amalgamated; but it will deliver a greater quantity of current in a given time than a gravity cell of equal size. The internal resistance of a new cell is about one-half an ohm. The plates should be removed and cleaned when the battery is not in use.

The Smee Battery, Fig. 4, consists of two plates of amalgamated zinc, between which is placed a silver plate coated with platinum, the object of the platinum being to fill the surface of the plate with innumerable fine points which aid in discharging the bubbles of hydrogen, which would cling closely to it if the plate were smooth and thus polarize the battery. This

battery is charged with a solution of one part sulphuric acid to seven of water. The plates are connected to the clamp and placed in the jar. In this battery, above all, the precaution of amalgamating the zinc should never be neglected. With an unamalgamated zinc the results are very unsatisfactory.

The voltage of the Smee, when not in action, is 1.09 volts; when in action it runs down to .482 volts; this is caused by the hydrogen clinging to the plate as described. This was the form of cell generally used before the introduction of dynamos for electrotyping and other heavy work, and it is still used to a large extent. It emits fumes of hydrogen when in action, but it is a single fluid battery and when working in large sizes, plates 12x12 inches in size are suspended in a large tank of acidulated water, first a plate of zinc, then a plate of platinized silver, then another of zinc and so on alternately, zinc and platinum. to the end. This gives great facility in handling, as any number of plates to suit the work may be placed in the tank. As there is but one tank and the plates may be placed close together or far apart as required, the resistance may be easily made to balance that in the

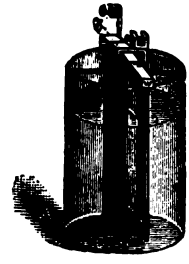

Fig 4.

depositing tank, and thus the work will be performed under the most favorable conditions.

In working the Smee, or any battery for that matter, large tanks are better than small ones, provided that the plates are kept close together so as to reduce internal resistance of the battery. In the large Smee, if plates 12x12 are worked in a tank say 15x15x30, it will not be long before the sulphate of zinc, which forms and falls to the bottom, will soon commence to rise in the tank, thus shutting off the acid from a portion of the plates and reducing the quantity of current. If the same plates were worked in a tank 24x24x30, the tank might be permitted to become half full of zinc sulphate before the action would be impaired at all, and thus a much more even and constant current would be maintained; this is generally done in practice. In a gravity battery, however, the tank ought not to be deep, because the two elements should not be more than eight inches apart on account of the increased resistance caused by the separation. The tank, however, may be large enough in length and width to contain elements of the desired size, or a number of standard zincs and coppers, if such an arrangement seems desirable, either to increase the facility of handling or reduce the cost of a large number of jars, wires, connections, etc. We

have seen a number of tanks made of wood, lined with lead, 10x10x60 inches, in which a single large copper element was placed at the bottom and a number of zincs hung as required from an insulated copper bar across the top. It seemed to work well and was convenient.

Varying Strength of the Current by Coupling.

A few words as to coupling batteries may be of service. It should be borne in mind that the quantity of current flowing in any circuit is the quotent resulting

Fig. 5.

from dividing the voltage by the total resistance in that circuit and that the resistance may be increased or diminished by increasing or diminishing the distance between the elements of the battery and between the anode and cathode in the plating vats, also, that the resistance varies inversely as the surface of the elements immersed. Thus a plating surface of one square foot in the plating vat will offer four times as much resistance as four square feet. It thus becomes possible by increasing or

diminishing the voltage of a current to keep the current flowing in the desired quantity, and by keeping the resistance in the battery about equal to that n the vats the highest economy is obtained.

For example, let us take eight cells, having a voltage of 1, and giving say ½ ampere per cell on short circuit. If we now couple them —,+,—,+,—,+,—,+, we shall have the voltage of 8 and the amperage of one cell of

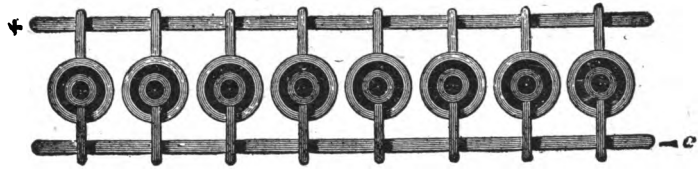

Fig. 6.

the same size, in other words, the same amount of current and eight times the strength of the single cell, as in Fig. 5.

This is termed coupling in series, and would be used in solutions having a high resistance and small amount of surface immersed. If, on the other hand, the solution had a low resistance and large surface exposed, so that the voltage of one cell was ample to force the current through the circuit, they should be connected +, +, +,+,+,+,+,+, and —, —, —, —, —, —, —, —, giving

the quantity of eight cells and the voltage of one, which amounts to nearly the same thing as if a single battery having eight times the surface of the single cell were used. This is termed coupling in multiple, Fig. 6. Similarly, if they were coupled +, —, +, —, +, —, +, — and +, —, +, —, +, —, +, —, and those two were joined as in Fig. 7, we should have the equivalent of a battery possessing a voltage of four, and elements twice the size of the single cell. This would be spoken of as a battery of eight cells in series of four. Also four multiples, in series of two, might be arranged to give a voltage of two and quantity due to cells of four times the size of a single cell, as shown in Fig. 8. As the amperes of current passing per second depends upon the voltage, divided by the number of ohms resistance, in the circuit, it will be seen that the current can be controlled by coupling and by manipulating the resistance.

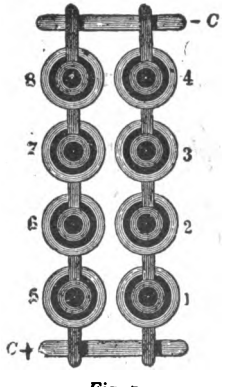

Fig. 7.

To Amalgamate Zincs. This may be very well done by first immersing the zincs in a solution of dilute sulphuric acid and then in a bath of mercury. A brush

or cloth may be used to rub them, so as to reach all points of the surface. Where a large quantity is to be amalgamated, the following will be found to be a good method: Dissolve eight ounces of mercury in a mixture consisting of two pounds of hydrochloric and one pound of nitric acid; when the solution is complete, add three pounds more of hydrochloric acid. The zinc is amalgamated by immersing it in this solution for a few seconds, quickly removing to a vat of clear water and rubbing it, as in the first case, with a brush or cloth. If the solution is kept in a covered vessel it may be used a number of times.

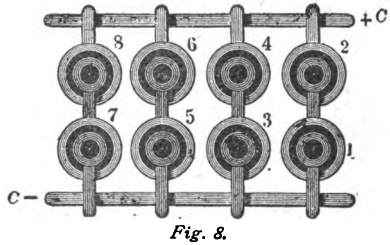

Fig. 8.

In all batteries in which acids are used the zincs should be kept well amalgamated and should be removed from the solution when not in use. This is very important and should not be overlooked.

Improved Electropoion Fluid. Add one part (by volume) of sulphuric acid to ten parts of water. Of 10 pounds (or pints) of the dilute acid, add from 1 to 2 pounds of chromic acid, according to the strength of current desired. Where constant action over a long time

is desired rather than maximum energy, omit part or all of the sulphuric acid.

Bichromate of potash is no longer used for batteries by intelligent workers. It owes its virtues to a small amount of chromic acid which can be obtained from it by reaction. Pure chromic acid is cheaper for the same work, and is free from many of the difficulties attendant on the use of the bichromate.

Connections. Having a knowledge of the theoretical action of the battery, the next question is the connections. Cleanliness cannot be too strongly insisted upon in making joints, etc. The plater should make it an invariable rule to see that all surfaces of wires, screws, etc., through which the current must pass, be kept bright on the surfaces through which electrical contact is made. When joining wires they should be brightened with a file, or with emery cloth, and then twisted firmly together with a pair of pliers; all permanent connections should be carefully soldered and the holes and the ends of screws in binding posts should be kept bright; and if for permanent use all conducting wires should be of pure copper, well insulated. The following table shows in the last column the loss of current in wires, carrying an economical amount of current; if the

wire be too small this loss is rapidly quadrupled until the wire burns. The economy of using large and short connections will be apparent after a slight study of this table.

Table showing the Weight, Carrying Capacity and Loss in Volts of different sizes Copper Wire.

Brown & Sharpe's Gauge No.	Diameter in Thousandths of an inch.	Pounds per 1000 feet bare feet.	Approximate weight Underwriters' Insulation, per 1000 feet.	Safe Current in Amperes.	Loss in Volts per 100 Ampere feet of line (2 Wire).
0000	.46	610.5	825 lbs.	312.	.0098
000	.40964	508.5	610 lbs.	262.	.0123
00	.3648	402.8	458 lbs.	220.	.0155
0	.32495	319.6	385 lbs.	185.	.0195
1	.2893	253.4	308 lbs.	156.	.0247
2	.25763	201.0	249 lbs.	131.	.0311
3	.22942	159.3	201 lbs.	110.	.0392
4	.20431	126.4	163 lbs.	92.3	.0495
5	.18194	100.2	133 lbs.	77.6	.0624
6	.16202	79.46	109 lbs.	65.2	.0787
7	.14428	63.01	90 lbs.	54.8	.0992
8	.12849	49.98	74 lbs.	46.1	.125
9	.11443	39.64	62 lbs.	38.7	.158
10	.10189	31.43	52 lbs.	32.5	.199
11	.090742	24.93	43 lbs.	27.3	.251
12	.080808	19.77	36 lbs.	23.	.316
13	.071961	15.68	30 lbs.	19.3	.399
14	.064084	12.43	25 lbs.	16.2	.503
15	.057068	9.86	21 lbs.	13.6	.634
16	.05082	7.82	18 lbs.	11.5	.799
17	.045257	6.20	15 lbs.	9.6	1.088
18	.040303	4.92	13 lbs.	8.1	1.271

CHAPTER II.

DYNAMOS, CONNECTIONS AND TANKS.

In the past, platers have been obliged to depend upon the battery in a great measure. This has often been found an unreliable source of energy. It is at the same time an expensive source of current, consuming valuable chemicals and costly metals, and giving a comparatively small return in current. Again, the battery for plating is objectionable on account of the mercury that is used to amalgamate the zinc. Mercury is the worst enemy to the electro-plater, it always being ready, even in the smallest particles, to amalgamate with his finished work and make black spots that cannot be removed except by re-plating. Fumes of acids used in the battery frequently cause annoyance and damage. It has been due to the above difficulties that the chemical battery has never come into general use, only being used when no other source of electrical energy could be obtained. When batteries are used, and the work does not come

out right there are several places to which the plater has to look for trouble. First, to the condition of the solution; then the plates, and then the acid-destroyed connections and contacts. With the use of a dynamo the operator at once has a reliable current, costing nothing when in idleness, except interest upon investment, and when in operation but a little for power.

The question of power is often one of the principal obstacles to the use of a dynamo. If you have no power in your shop, and no way of getting it, a dynamo cannot be used, and in this case batteries will have to be coupled together and enough of them used to take the place of a dynamo.

If power is available, it would be a false economy to use anything but a dynamo. The original cost is more, but the facility for doing work is greatly increased; there is then no variation in current, and a dynamo requires practically no attention.

A dynamo depends for its current upon the fact that a copper wire, passed between the poles of a magnet, will generate a current of electricity in the wire; this current bears a definite relation to the strength of the magnet and the number of times the wire is passed between the poles. From this it will be seen that the size of wire, the strength of the magnet and the speed of revolution

all have a bearing on the current produced and that by altering the various factors given above we can obtain the quantity and strength desired. Before dynamo building had attained its present state of advancement, great difficulty was experienced in producing currents of *low voltage* by this means, and the older dynamos were

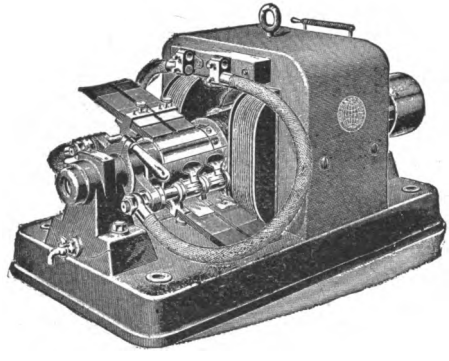

Fig. 9.—A Modern Dynamo.

very apt to burn the work; hence the notion, still held by many old platers, that the dynamo is unsuited to do really hard and durable plating. This is completely overcome in the modern dynamo and the much lower speed of the modern dynamo makes them at the same time less expensive to run and more durable and longer lived. Therefore the plater who is tempted to buy a second-hand machine, on account of its low price, may

find it the most expensive machine he could use, and be finally obliged to throw it away and get something up to date in order to get the cost of producing work down to a figure that will leave him any margin at all. When buying a dynamo, see that it is a modern machine.

See that it will do *your* work.

See that it does all that is claimed for it.

See that it does not require constant attention.

See that you get a constant, steady current.

You want a machine that will not spark.

You want one in which you can control the current.

You want one that will not reverse, or heat.

You want one that is noiseless.

Get one that is *not overestimated* in capacity.

Get one having all parts interchangeable.

Get one that when *taxed* to its *utmost capacity* will not *drop its current.*

Dynamos and motors capable of giving the best results for a short time may be constructed with very little regard for mechanical principles. In selecting a dynamo or motor, the fact that the machine is to be used for many years, under heavy strain and subject to little attention, should not be overlooked. Its continued electrical efficiency is dependent on a high order of mechanical excellence.

Setting Up and Running. The dynamo should rest on a solid or substantial foundation as near to the tanks as convenient, and be placed at a height that will give your plater easy access to all its working parts, especially room to set or adjust brushes, as a few minutes' attention each morning adds greatly to its efficiency, and keeps commutator and brushes in good condition.

See that the dynamo rests firmly on its foundation, as absence of vibration adds to the life of the machine and insures a more uniform current.

Set the brushes so that they come in contact with the commutator both top and bottom so as to be directly opposite. To avoid sparks, keep brushes beveled, and avoid letting under leaves drag. Carefully adjust the brushes without too great pressure, to insure perfect contact between brush holder and rod. Too hard pressure will cut the commutator. The brushes are furnished beveled, and can be kept so by filing. Occasionally the projecting part or end of top leaf can be trimmed. A little care in adjusting brushes so as to get the bevel resting squarely on the commutator will prevent sparking. Sparking at the brushes does not necessarily indicate a fault in the armature. It is more probably due to imperfect adjustment. To remedy, move

the rocker arm back and forth, and if the sparking does not entirely cease, alter tension of brushes. See that they bear on commutator the full curve of brush face. *There is but one non-sparking point*, and after the rocker arm is adjusted to this, do not move it. It is not intented to regulate the current or speed. Lubricate the commutator with vaseline and plumbago mixed and apply with a piece of hard felt. If commutator shows signs of roughness, smooth it with a piece of fine sand paper, and then lubricate. Never use emery cloth or file. If badly roughened, take armature out and turn commutator off in a lathe. It is a mistaken idea that brushes must bear hard on commutator. Only pressure enough to preserve good contact is required. The commutator, to be in perfect condition, should glaze over and show no appreciable wear. It may be kept so by skillful handling of the dynamo. When the commutator once becomes glazed, it is an indication that the brushes are in the right position, and it will not require sandpaper for months; simply use the oil and plumbago. One man should have charge of the dynamo and be held responsible for it.

Connections. The matter of battery connections has been fully covered in the chapter on primary batteries

and the method of connecting the battery and tank for small work will be fully understood by reference to Fig. 10, while the importance of the size of wire used for conductors, etc., is fully detailed in the table on page 27.

The arrangement and size of connections for dynamos in larger shops, using a number of tanks, is, however,

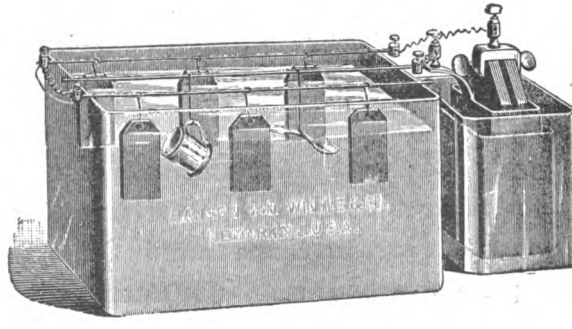

Fig. 10.

a very different matter. Here the plan is to use two large conducting bars running from the dynamo past the various tanks and to take the current from these bars by means of wires or rods leading to the various tanks. False economy is often practiced here and, as usual, it leads to trouble. One instance will be sufficient to explain what is meant. An electrotype foundry purchased a dynamo when starting in business, and, objecting to the cost of solid copper bars of the size pre-

scribed by the dynamo manufacturer, used large brass tubing instead. Everything went well until business grew so much as to completely fill the tank with work, when they found that they could not deposit the copper in the required time. Naturally they thought they needed another machine; the old one was not up to its rated capacity, etc., etc., and the salesmen of various dynamo builders looked solemn and tried to sell them a machine to replace the first one. One day the agent of the first one happened along, heard the story and calmly said: "You don't want another machine. Get your new solution into your new tank and come along with me, while *I buy* the conductors and *you pay* for them." It was done; the agent bought 1¼ inch solid copper rods to replace 1½ inch brass tubes, and the dynamo thereupon deposited the copper within the required time with *both tanks full of work*, while with the tubes as conductors it had failed to do it with one tank full. This will give an idea of the importance of putting a little money into copper when it is called for in the plating room. The expenditure occurs but once and it should be ample at the beginning. Take the advice of the dynamo builder in regard to the conductor bars for his machine. It will cost you money if you don't.

The bars should be put up in such a way that things cannot be hung upon them or fall across them. Unless this is done there is a constant temptation to the workman to hang wires, hooks, etc., upon them, and short circuits will be frequent. When this is the case the entire force seems to get rattled and blind. A large plating establishment had a large nickel tank, copper tank, and a small brass tank all go wrong suddenly one morning. Do what they would, they could not find the trouble. They telephoned to a dealer and asked for an expert. He listened to the details and said: "You don't want me up there; you've got a short circuit somewhere; find that and you'll be all right." At two o'clock they telephoned again. He *must* come out there. He went, and the first thing he saw on entering the room was an iron crowbar leaning against the main conductor bars, ten feet from the dynamo. That crowbar cost the wages of ten men for half a day. Short circuits are expensive. They have also been caused by fastening the conductors to damp walls without anything between the wall and the conductor.

All permanent connections from the conductors to the tanks should be soldered when possible, as it obviates the necessity of keeping a constant watch on all joints, which must be done when screw clamps are used.

Regulation of the Current. When the dynamo is employed on several tanks at once the current must be regulated for each by interposing a resistance switch between the conductor and tanks. This is always put in on the positive bar and connected with the positive bars of the tanks. Fig. 11 illustrates such a switch.

In using switch boards or rheostats, they are put up as

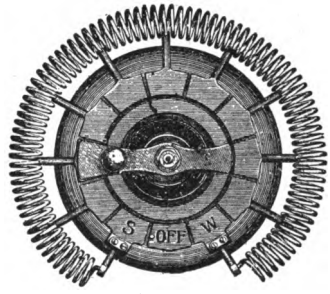

Fig. 11.

near the tank as possible. The switch should rest at W, or weak point, while putting work into the tank, and should then be turned towards the strongest point until suitable current is obtained. These resistance coils are used to prevent "burning" the work, as if burned the deposit becomes brittle, and very hard to polish. Where several solutions are required separate switch boards should be used with each tank.

All platers understand that different voltages are required to operate successfully different kinds of solutions, and that when a sufficient voltage is to be generated for a solution of the highest resistance, and at the same time utilized in low resistance solutions, the tank nearest the dynamo, with the customary method, receives the most current, and a tendency to burn and blacken is noticed to a marked degree. When metals such as silver and copper are to be deposited in connection with such metals as nickel aud brass, a higher electro-motive force is required, and considerable drop in voltage is demanded in the lower resistance solutions, so as not to blacken the work.

Measuring Instruments are often a necessity in studying the conditions under which work is done, and if used will save their cost every month in any large establishment, by enabling the plater to know exactly what quantity and strength of current he is using. This is especially true of mixed solutions for the deposition of more than one metal, such as brass, bronze and other alloys. Even on single solutions they are frequently of great service. The observing, practical electro-plater will know that the character of the deposit obtained in a certain solution with a definite area of objects to be

plated, depends largely upon the reproduction of certain conditions, and especially upon the tension of the current for the certain area to be plated. To reproduce such conditions it is highly important that either the electromotive force existing between anode and cathode, and the current flowing through the same, be accurately

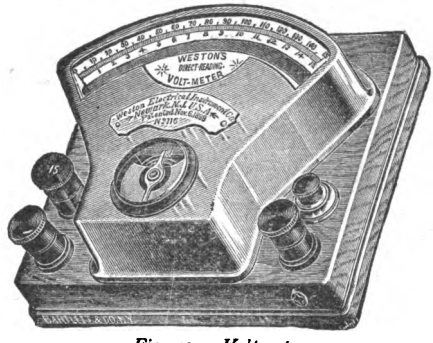

Fig. 12 Voltmeter.

determined in order that they may be reproduced at will. The ordinary galvanometer is insufficient and often misleading, and not at all satisfactory for the actual measurement of either the voltage or current; it indicates only a change of polarity. If it is desired to measure actually the E. M. F. existing at the terminal of the dynamo or bath, only the very best voltmeters or ammeters should be used. They should be so constructed as to indicate quickly and accurately any

sudden changes in current, and should be direct reading in volts and amperes, and their indications should not be subject to gradual changes. A sensitive voltmeter will indicate the slipping of belts, short circuiting in tanks, and any irregularities in power. The general acknowledgment of the absolute necessity of these measuring

Fig 13. Ampere meter.

instruments has increased the demand to such an extent that they are now quite reasonable in price.

Whilst it will be sufficient in most cases to use a voltmeter in combination with a rhoestat for regulating purposes, it will sometimes be found desirable to determine the actual amount of current in amperes passing through a tank. It is a fundamental law of electrolysis that a certain number of amperes passing through a plating solution will cause a definite weight of metal to be

deposited. So, for instance, one ampere will deposit in one hour 1.106 grammes of nickel, or 4.05 grammes of silver. It is evident, therefore, that by means of an accurate ammeter the amount of metal actually deposited can easily be determined.

Tanks.—The plating jars, tanks or vats should be of glass, glazed stoneware, enameled iron, or of wood lined with asphaltum. The latter are always used where the baths are large and in constant use, as they are the only ones that are sufficiently strong to withstand hard usage, such as is incident to the handling of large pieces or a great number of small ones. These tanks should be purchased of a dealer in platers' supplies, or from tank manufacturers, as it is not advisable to risk the loss of solution and the consequent damage to surrounding objects from a poorly seasoned, poorly fitted or improperly lined tank.

New tanks of wood are generally shipped unlined, as, if the weather is cold, the asphaltum will be cracked in handling the tank, and if the weather be hot the lining is likely to be found evenly spread over the bottom of the tank to the depth of six inches or more, while there is nothing on the sides. Tanks have thus had to be relined so often that the custom is now to send the tank

and the lining and let the plater line it himself. One of the best ways to line a tank is to stretch cheese cloth all over the inside, tacking it down neatly on the bottom and all four sides; then nail a strip of wood on the upper edge of the tank, so that it projects about one-fourth inch beyond the inside edges of tank; lay the tank on

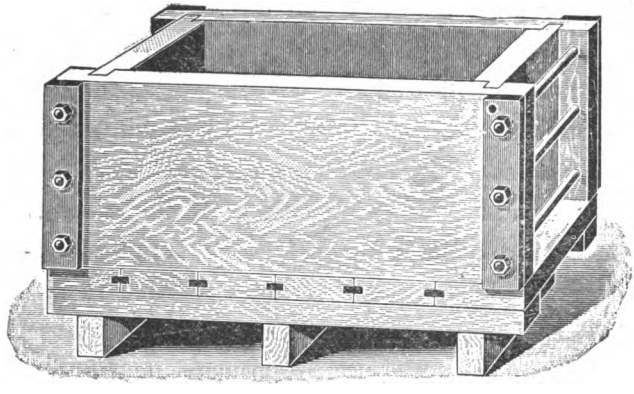

Fig. 14.—Wooden Tank for Platers.

its side, level it up and heat the lining and pour it in on the cheese cloth until it stands even with the strip of wood you have just put on; allow this to cool and repeat for the other sides, doing the bottom last. The cheese cloth strengthens the lining and prevents it from cracking, just as hair is used to strengthen plaster. Tanks lined in this way will stand for years. They should

always be deep enough to leave about six inches between the bottom and the largest work. To find the capacity of any tank, multiply the length, breadth and thickness in inches and divide by 231, as 231 cubic inches make one gallon.

Square or round iron tanks, Fig. 15, are used for potash, hot water, etc., and are made in the same shapes

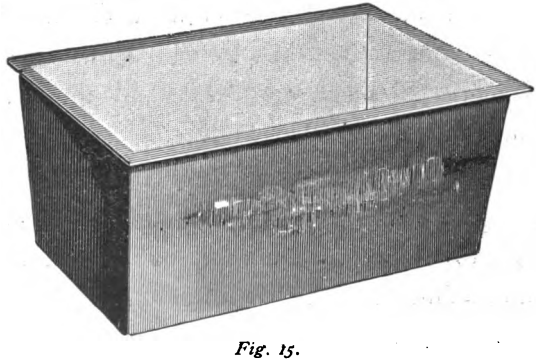

Fig. 15.

and sizes as the enameled iron tanks used for plating solutions. It is best to buy these of dealers in platers' supplies and not from plumbers, as the tanks of the latter are frequently very thin and of inferior iron, and are liable to break while in use and cause damage amounting to five or six times the difference in cost.

The platers who are working in a small way will find the best quality of enameled iron cooking utensils serve

their purposes very well, but in selecting agate or blue enameled basins, pitchers, cups, pails, etc., a very close watch should be kept for flaws in the enamel, for if the solutions penetrate to the iron they will be destroyed. White enamel is usually selected for this reason, as it is much easier to discover imperfections in the white enamel than the gray or blue. It also enables the workman to see the color of his solution better, which is sometimes an advantage. Stoneware crocks and jars are also in constant use in plating rooms, to hold the various acids, pickles, dips, etc., and the same care should also be used in selecting them.

Heating Tanks.—Small shops usually depend upon gas or oil stoves placed under the various tanks or jars containing solutions that must be kept hot, such as lye, rinsing water, gold solutions, etc , as either offers a means of keeping up the desired temperature with very little trouble or expense. Larger establishments, however, find it cheaper and better in every way to use steam jacketed tanks, as shown in Fig. 16. These can be purchased in regular sizes, holding from three gallons up to forty gallons, and the smaller and medium sizes are rapidly finding favor in many machine shops and factories where it is important to cleanse the work quickly and cheaply

Still larger tanks for heavy work are made of boiler iron and heated by a steam coil placed in the bottom of the tank; this usually is allowed to simply lie upon the bottom of the tank, so that it may be readily removed

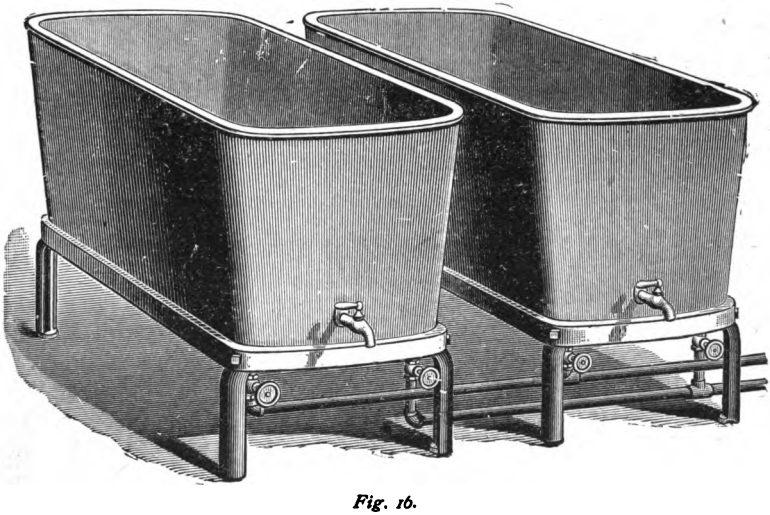

Fig. 16.

should it become necessary in cleaning the tank or repairing the coil.

In arranging the tanks in the plating rooms, much will depend upon the work to be done and the space that is available; the only rule that can be given, therefore, is to follow the order in which the work is handled in both polishing and plating rooms, so that little time and labor

will be lost in carrying work back and forth, with the consequent dripping of the lye and acids, etc., upon the floor. In large establishments it is frequently an important item to have the work thus proceed in a straight line, and where it is necessary, that tanks for hot water and lye, dips, etc. are duplicated, to avoid carrying the work about. Smaller establishments will, of course, be governed largely by circumstances in the arrangement of tanks, sawdust boxes, etc.

CHAPTER III.

THE POLISHING ROOM AND TOOLS.

Polishing should always be done in a separate room, in order to keep the plating room clean and thereby prevent the expense and annoyance caused by dirt and dust in the solutions. In large shops this is regarded as a matter of course; but many small platers think that a separate polishing room is not necessary; that they can cover their solutions and get along very well without going to the expense of partitioning off a place to do their polishing. The consequence is that their shops always look as if they had not been cleaned in six months; a thick coating of dirt covers the walls, benches, countershafts, tools, machines, etc., until it is actually a fact that the cleanest place in the shop is the floor. This sounds severe, but if the reader will go into such a shop and draw his finger along the walls he will find it to be a fact. The floor is swept daily and the walls are never cleaned. Polishing is a very dirty

operation; the lint from the cotton and felt wheels, minute particles of leather, emery, oil, tripoli, crocus, wax and finely divided metal are continually flying from the wheels and work and this dust penetrates everything. These are the platers that turn out poor work and do not see why they cannot do as well as their neighbors. Dirt is fatal to good plating and dirt is inseparable from polishing.

Buffing and finishing after plating should also be done in a separate room for the same reason. Many platers have frequent trouble from scratching their work while buffing, often making it necessary to replate the article. Nine times out of ten such coloring or buffing was done in the polishing room where some heavy work had been recently done and the coarse emery or scale from the work had lodged on the finishing wheels. We are speaking now of shops which take rough work and finish it. The little shop with a specialty, such as gold and silver only, or such other work as replating, etc., where heavy cutting down is not done, will hardly go to the trouble of duplicating the heads, countershafts, etc., in order to separate the work in this manner, preferring to take chances on scratching, etc., rather than go to the expense and trouble of separating the polishing and finishing, but wherever practicable it will pay to do it, and

in a manufacturing establishment or large jobbing shop it is a necessity.

Ventilation in a polishing room is of great importance to the health of the workmen and should always be forced where possible, by a blower exhausting up a chimney or into the outer air, with pipes leading from the blower to hoods about the various wheels, buffs, etc., and these pipes and blower should be large enough to maintain a constant current of air about the wheels and away from the workmen. Men will do much more work in such a room than in one in which they are obliged to gasp for breath with wet sponges over their nostrils, so that the power thus expended in driving a blower has an important result in cheapening the cost of running a polishing room.

The Machinery in this department of plating has undergone important changes in the last few years, so that more work and greater cleanliness can be obtained with the modern machine. The old machines had the shafts hung on centers from a clumsy wood or iron frame, built in such a way that it was never cleaned, because it was too much trouble. The modern machine, Fig. 17, has a long shaft running in babbited boxes on

each side of the driving pulley and the yoke which carries the shaft is mounted on a stout iron column. This arrangement not only gives greater facility in handling the work, but also preserves the perfect alignment of the boxes and even running of the shaft, which was not

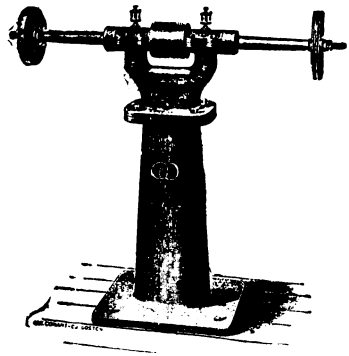

Fig. 17.—Polishing Head on Column.

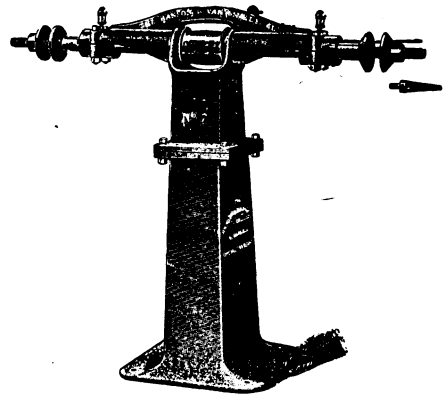

Fig. 18.—Polishing Head for Heavy Work.

always the case with the old style of frame, owing to the springing of the floors when heavy weights of castings are piled near the machines, as is usually the case in large shops. The column also offers no obstruction to sweeping and shops using them are kept much cleaner.

Machines for heavy work, Fig. 18, have an upper yoke carried on the lower yoke and having boxes

free from emery, which would immediately sink into the babbit metal and act as a lap, cutting out the shaft very rapidly.

Bearings not provided with closed oil cups should have covers of tin or brass over the oil holes and the foreman should see that the covers are kept in place. If there is room for it in the cups, a little cotton waste laid in them and changed as fast as it gets dirty will do a great deal towards keeping emery out of the bearings of all machinery in the polishing room.

Where possible the machines should be arranged so that the workmen stand facing the light, as this permits them to see what they are doing without stopping and turning their work about, thus enabling them to do more work in a given time than they could if the light came from another direction. This may seem a trivial matter, but any polisher will assure you that it is not, and in a business where the chief expenditure is for labor, every saving of time is important, especially where a large number of men are employed.

Glass or metal shades should be placed over each wheel to protect the eyes of the workmen; sometimes this is obviated by extending the hoods far enough over the wheels to serve as a shield. When this is done the

hood is made so that it may be readily slipped back upon the blower pipe when changing wheels, etc.

Rattling or Tumbling Boxes. Small objects, such as small castings, stampings, etc., that are not required to have square edges, are best cleaned by tumbling, or rattling, as it is called in foundries. Large quantities of work are thus easily and cheaply cleaned without much manual labor, which is the expensive item in polishing. If rough castings are being worked, the sand, scale, etc., adhering to them is allowed to remain in the barrel, where it acts as a polishing powder, brightening the parts which are not reached by the metal of other castings; but when tumbling for a bright finish, the sand, dirt, etc., are exhausted by means of the blower, so that the surfaces are finely polished by friction only—burnished, as it were, by rubbing against other metal of the same kind. A strong exhaust should be kept up when polishing in this way or the finish will be dead instead of bright. It is a principle in burnishing that you cannot get the burnished surface smoother than the burnisher, so that a little consideration will show that bright work is only obtained by long-continued tumbling, and the bright finish comes rather quickly after all the pieces in the barrel have become smooth. It is, therefore,

necessary to handle the work in batches, and not to add more work after the batch has been some time in the barrel, or the work will not finish evenly, and time

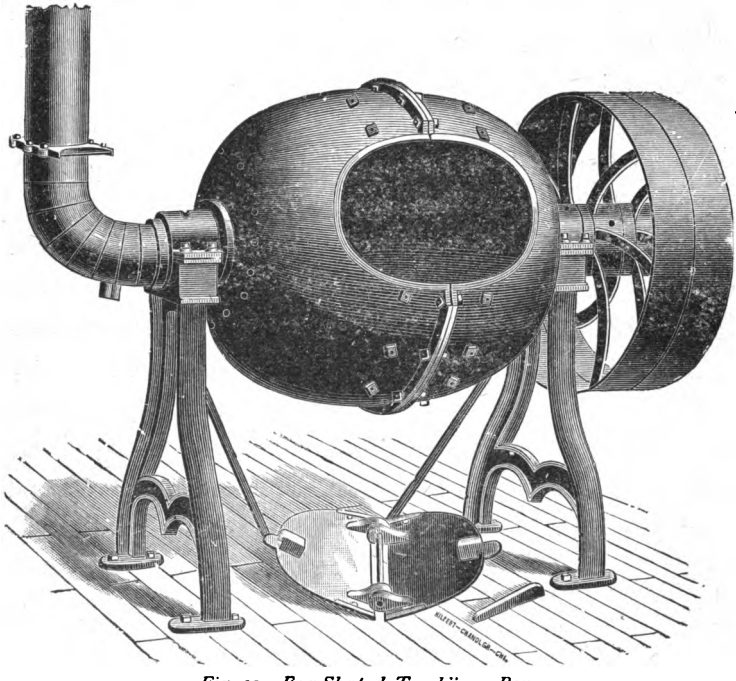

Fig. 21. Egg-Shaped Tumbiing Box.

will be lost instead of gained. The speed should be regulated so that the articles may have time to slip down upon and slide over each other as much as possible. If the barrel turns too fast they will hug the sides

of the barrel and be carried around with it; about 40 to 50 revolutions is correct; if too slow, the action is unnecessarily prolonged. Fig. 21 shows a new form of tumbling barrel far superior to anything else within our knowledge. The barrel is egg-shaped; it has a section of exhaust pipe connected to the hollow journal at one end and a tight and loose pulley at the other end. No gearing whatever is used. Three special advantages are found in the egg-shape:

It gives the contents a double motion or action—from ends to center and from sides to center—causing a thorough mixing and rubbing together of all the parts contained therein, cleaning and polishing the contents better and quicker than any other form of barrel.

It requires less power, as the end motion causes the contents at the ends to tumble into the center because of assuming the perpendicular earlier than those parts at the side.

It runs with less noise, because the contents are kept moving in two directions at the same time, doing away entirely with the intermittent motion so noticeable in other forms; doing away with gearing also lessens the noise.

It is lined with a sectional lining of hard iron, which can be cheaply and quickly replaced when worn out,

making the barrel as good as new. A current of air is forced through the barrel by an exhaust fan, which removes the dust and carries it out through pipes arranged for the purpose, and the room is kept perfectly free from this nuisance. The workmen are thus enabled to do their work comfortably. It is said to do more and better work, take up less room and requires fewer barrels for a given amount of work than any other. Small sizes of the barrel, for finishing small work ready for plating without hand labor, are now being made.

Emery or Corundum Wheels are used for grinding off the lips of castings, imperfections caused by breaks in the moulds, etc. These wheels are of varying thicknesses, grades, sizes and shapes and should be run at correspondingly varied speeds in order to get the best work out of them. The same grades of wheel from different makers sometimes vary slightly in speed and these details had therefore best be obtained from the manufacturers. If run too fast they will glaze and require dressing to keep them sharp. Too much pressure when grinding will also glaze a wheel. The grinder should understand dressing wheels, as it is often necessary in balancing them, as well as in keeping the surface true and sharp.

Flat wheels are dressed with an emery wheel dresser, a tool generally listed by dealers and therefore unnecessary to describe here. Curved surfaces, mouldings, ogees and angles are ground with wheels specially turned up by the workmen to fit the surface, in order to do the work quickly while preserving the shape; as in preparing stove work for nickeling, etc. This turning is best accomplished by using a diamond turning tool, which can also be found in the market. Such wheels when glazed are also dressed with the diamond tool. Work having hollows too small for the large wheel is ground with a large and small wheel on the same arbor. This holds true in polishing as well.

Canvas Wheels are next used on all large surfaces. These are made of coarse duck or canvas, cut into discs of the required size and glued or cemented together under pressure, after which they are bored out to receive the arbor, put on the machine and turned up to the required shape with a wood turner's tools. Some shops make their own canvas wheels, but it is generally cheaper to buy them. Both glued and cemented wheels have their advocates. The former claim that there is little difference between them, and glued wheels are cheaper; the latter declare that a glued wheel is too hard

and will not polish uneven surfaces as well as a wheel well made with a flexible rubber cement, and that a slight increase of cost is more than made up by speed in polishing. It is a matter which every polisher will decide for himself, according to the nature of his work. Canvas wheels are set up like wooden wheels. The grade of emery will depend upon the nature of the work to be done. If very rough and coarse iron surfaces are to be worked, No. 70 emery is first used, followed by No. 90; if the surface is fairly smooth, No. 90 is used at first followed by No. 120. If the metal is brass, tripoli is used for cutting down.

Wood Polishing Wheels, Fig. 22, are made of thin sections of pine, glued together with the grain crossed, bored and turned up as previously described, and finally, if flat, covered with best oak tanned leather, glued on the rim and turned up true, if it needs it. These wheels are set up by covering the leather with hot glue and then rolling in powdered emery of the desired grade. Right here is a source of frequent trouble. It often

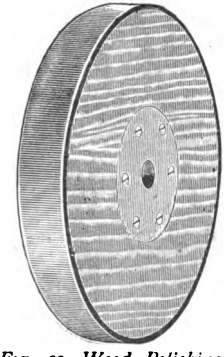

Fig. 22—Wood Polishing Wheel.

happens that in gluing up a lot of wheels of different grades the loose particles of emery on the 70 wheel will get into the glue brush and be deposited on a 90 or 120 wheel. Nobody sees it, of course, until the polisher finds that he cannot get the scratches out of his work until he changes wheels. Much time is often lost in this way. The remedy is to have separate glue pots and brushes for the various grades. When the emery is no longer sharp it is soaked off the wheel and fresh powder again glued on. It is customary to glue and set up wheels the last thing before quitting work at night, in order that the glue may have all night to dry and thus get thoroughly hardened, so as to give the best service. Only the very best glue will stand the work.

Polishing Wheel Cleaner. Users of leather covered emery wheels should use a cleaner. By placing the worn wheel in this machine and letting it run a few minutes with the water just touching the rollers, all of the glue and

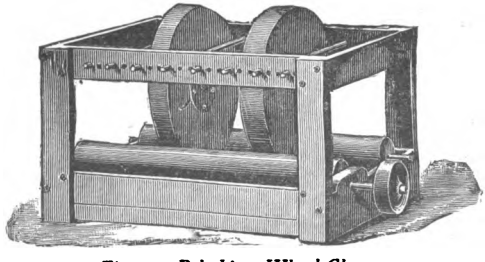

Fig. 23—Polishing Wheel Cleaner.

emery will be removed without damaging or loosening the leather covering. This machine, Fig. 23, has two rows of movable rods (only one shown in cut), to keep the wheels from falling over. The idle roller also has two positions for different diameters of wheels. As it requires no attention or time to use it, the cost of this machine will be saved in a few week's labor. Speed should be about 20 revolutions. The other wheels, which would be injured by water, are cleaned with buff sticks which are made by gluing a stick and dipping in No. 15 to No. 36 Emery.

Leather Wheels are used in polishing and fine grinding, where a flexible wheel is necessary. There are many different kinds, which may be classed under this head, and while every polisher has his preferences, if he has not the kind he prefers, he can use another.

Walrus Wheels are made from the thick, specially tanned hide of the walrus, and are unequaled for work requiring the wheel to be turned up to a thin, moulded edge or curve, as they are thick enough to allow such shapes to be made from a single piece, while the thinner discs of other leathers are apt to leave ridges of glue where it will mark the work unless greater care is taken.

Bull Neck Wheels are made, as the name indicates, from the thickest and toughest portions of hides, and form a harder wheel than walrus. They are much used in stove, bicycle and other steel and iron work, and are turned and glued up as previously described. The other leather wheels are similar in their nature, differing only in the mechanical structure and degree of hardness, the desirable quality being the ability to hold the emery up to the work without allowing any lumps or unevenness in the glued emery to cut into or gouge the work; this becomes more and more important as the finishing proceeds, or softer metals than iron are being worked, and so still softer wheels are used, made from felt.

Felt Wheels are used with emery and glue, or with polishing compositions. They are of varying degrees of hardness and either white or gray. Certain peculiarities of felt wheels, though well known to professional polishers, have never, to our knowledge, been printed, and it may be serviceable to mention them here. The first point is that the higher priced wheels are the cheapest, the extra price being more than made up in the increased durability and uniformity of the white wheels, which wear much longer, balance better, and give a

superior finish, than do the cheaper gray felt. The second point lies in the fact that the wool in a felt wheel will catch fire under too hard pressure, and once ignited it will smoulder away under the emery and glue until it has burnt a long hole in two directions through the felt, without showing any signs until the coating breaks in from the surface, and the wheel, being then out of balance, begins to pound. The only thing to do, in such a case, is for the workman to turn the wheel down to where the felt is solid and start over again. Burning is always the result of carelessness, and it is amusing to hear a workman claim that the hole was there when he got the wheel, forgetting that in such a case the wheel would be out of balance and he could not have run it that way without balancing the wheel.

Cotton Buffs, Figs. 24, 25 and 26, are made of discs of muslin and are used with pastes of tripoli, crocus or rouge, for finishing or coloring. They vary in softness according to the nature of the work, their material and the method of manufacture. The hardest buffs are made in sections, from duck, stitched or quilted together,

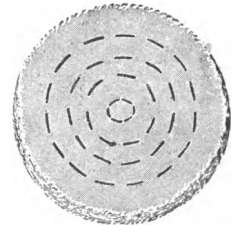

Fig. 24—Medium Buff.

while the soft buffs are muslin stitched only at the center. As many sections as may be necessary to make the desired thickness of wheel are put on the arbor and the flanges set up until the wheel runs properly. Too tight flanges will cause the buff to spread

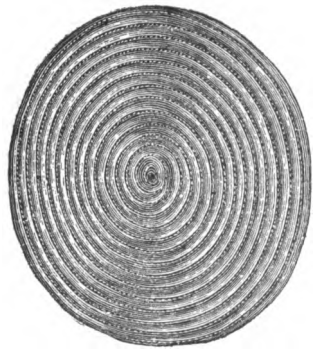

Fig. 25.—Hard Buff.

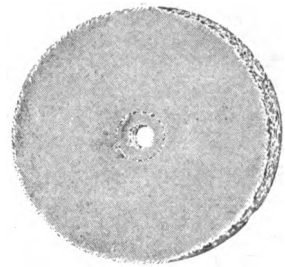

Fig. 26.—Soft Buff.

and run unevenly; if too loose, the wheel will slip, making bad work.

Grease Wheels. When a leather covered wood, leather or felt wheel has had the emery on it worn down smooth by use, so that it no longer cuts freely, a little tallow or oil is applied to its face, a little 180 emery cake or polishing paste is applied and the work gone over again. The wheel thus prepared is called a grease

wheel. Grease wheels are made only from wheels set up from 120 or finer emery. The work is then gone over again, without oil or tallow on the wheel, and this use of a worn grease wheel is known as "dry fining." After the grease wheel is worn down perfectly smooth, a little pumice or polishing paste is applied, a flint stone is held against the face to glaze it over and at the same time remove any particles of sharp emery that may still be there and the work is gone over a fourth time. This is known as coloring and produces the highest finish on steel, leaving the work lustrous and beautiful in appearance. This final polish has a great influence upon the appearance of the plating and practical men can tell at a glance in looking at plated steel, whether the polishing was a "three wheel" or "four wheel" operation.

In such cases it is customary, when doing small work, to place the fining and coloring wheels side by side on the same arbor, separated by collars, so that the successive operations may be done with one handling.

Belt Straps are made of canvass or duck, from one to two inches wide, glued and set up with emery as previously described, and used in polishing flat surfaces, such as cutlery, flat springs, large tubes for bicy-

cle frames, etc. They are run on flanged pulleys, one of which is supported on a standard and the other, which is the driver, is mounted in place of a wheel on one of the polishing heads.

Balancing Wheels. All wheels running as fast as they must in polishing, require to be very carefully balanced or they will "pound" or "chatter," making good work impossible. Balancing is accomplished by placing the wheel on an arbor and rolling it on two level, knife edged strips of metal, one on each side of the wheel. Thus suspended the wheel will stop with its heaviest part downward, and with a little chalk to mark the wheel and some small pieces of sheet lead to fasten on the side of the wheel, balancing is quickly and easily performed. It may also be done by hanging the arbor between spur centers, as pulleys are balanced in a machine shop, but the rolling method of balancing on bars, which is precisely the method the watchmaker employs in poising a watch balance, is the quickest and best. Balancing should not be done until the wheel has been turned true on its arbor and glued up. It should never be omitted. A properly balanced wheel will run true, even and noiseless at any speed.

Speed of Wheels. Wheels and buffs are run from 2,000 to 2,500 revolutions per minute, depending on their size and the nature of the work; and here we would like to make a suggestion which will materially increase the output of any polishing shop. If we examine the table of emery wheel speeds given herewith, we shall find that the speed increases rapidly as the wheel gets smaller. Most people imagine that this table is merely a guide to the safe running speed of the wheel and that it is given in order that the wheel may not burst while running. This is an error; the table simply means that the given number of revolutions for any size of wheel is that which will drive the circumference or cutting surface of the wheel at its proper cutting speed to enable the wheel to do the best work and the most of it. Machinists understand the point thoroughly, and their shops are filled with cone-pulleys to enable them to keep up the cutting speed

Diameter in Inches.	Revolutions Per Minute.	
	Minimum.	Maximum.
1	18,000	18,000
1½	10,000	14,000
2	7,900	11,000
2½	6,330	8,800
3	5,275	7,400
3½	4,500	6,300
4	3,950	5,500
4½	3,500	4,900
5	3,160	4,400
6	2,640	3,700
7	2,260	3,160
8	1,980	2,770
9	1,760	2,460
10	1,580	2,210
12	1,320	1,850
14	1,130	1,580
16	990	1,380
18	880	1,230
20	790	1,100
22	720	1,000
24	660	920
26	600	850
30	500	735
36	400	
42	350	
48	300	

on work of varying sizes. In the polishing department this is neglected. The pulleys and countershafts are arranged to run the largest wheels properly, and when they are turned down from time to time, the work simply proceeds more and more slowly until the wheel is worn out and a new or larger one substituted. Now, it is useless to tell a polisher to keep up the cutting speed of his wheels unless you give him the means of doing so. There should be four-step or five-step cone pulleys on the line shaft for each machine, belted to the other cone of the pair, on a jack shaft which also carries the driving pulley leading to the wheel arbor of the machine. This would enable polishers to speed up as their wheels got smaller, and the increased output of the shop would repay the outlay several times over, each year. The cones could be made of wood, and would add nothing to the weight and consequent wear on the line shaft. Now that so many large shops are being fitted up regardless of expense in order to get a great output of work, this is a point that should not be neglected.

Direction of Polishing. In all polishing operations the successive grindings should constantly cross one another as far as possible, otherwise the scratches will

not be taken out, and the work will not have an even, mirror-like polish. The wheels should turn so that the lower edge moves away from the workman and the work is held up to the wheel on its under side, so that the dirt, grit, etc., will fly back into the hoods, while the work, in case of accident, would drop away from the wheel instead of falling on it, as would be the case if another position were chosen for the work. The pressure should be light and even and the grinding should, in each case, be continued as long as any of the scratches made by the coarser previous operation remain on the work; when only the marks of the wheel in use can be seen, the work may be considered ready for the next operation.

Polishing Materials. In order to hold fine powders on the wheels and buffs they must be mixed with some medium that will perform this office, and at the same time act as a lubricant to the work. It was formerly customary for polishers to buy their powders and mix them with varying proportions of oil, tallow and beeswax, which was then cast into blocks. The objections to this were lack of uniformity and the use of too much oil, wax, tallow (or all three) in proportion to the amount of powder, which had a tendency to "stuff" (or fill up)

the buffs so much as to interfere with their working properly. The manufacturers of polishing powders have taken up the question, and succeeded in turning out cakes that combine all the necessary qualities of such a composition—namely, the largest proportion of powder with the least amount of binder, and a cake that is hard enough so that a small amount of composition may be evenly distributed over the entire cutting surface of the buff by holding the cake against the buff while it is in motion, and the paste so it will cling to the buff, leaving the metal clean. The manufactured cakes also have their keeping qualities greatly improved from the absence of soft greases, which are liable to turn rancid, and thus injure the working qualities of the cake. These polishes are generally designated by the manufacturer in such a way as to show the metal they are intended to be used upon, and the grade of the polishing material as: Nickel Rouge, Hard No. 1; Nickel Rouge, Hard No. 2; Nickel Rouge, Soft; Silver Rouge, Hard; Silver Rouge, Soft, etc. When ordering these polishing materials the purpose for which they are to be used should always be stated, as the order can then be filled with that variety which is best adapted to the work in hand; and cleaner, quicker and better work will thus be produced with less waste of material.

Tripoli is used in three grades—coarse, for cutting down rough or hard brass, etc., on hard buffs; medium, used on medium buffs for smoothing, cutting down softer metals, etc.; fine, on soft buffs, for coloring only on cheap work, and for use in place of the harder rouges where the color of the latter is objectionable, and it is difficult to get it out of the work. The various manufacturers have special names for their different grades, but it will be sufficient when ordering to state the kind of work and buff you intend to use the cake upon.

Crocus is an oxide of iron, made by calcining sulphate of iron in great heat and then grading it into polishing powders. The more calcined part is of a bluish purple color, coarser and harder than those portions which have had less heat, and is called crocus, while the softer and redder portions of the charge are called rouge. Crocus compositions of various grades are largely used for coloring iron and steel.

Rouge is softer than crocus, and is used for coloring brass, gold, silver and the softer metals. It is divided into numerous grades, which are distinguished by the names of the metals for which they are especially adapted, as: silver rouge, gold rouge, etc. Its red color

makes it particularly adapted for brass, gold, and some other metals where the reddish tinge sets off the color of the metal on which it is used. The finest, or gold rouge, should be used on canton flannel buffs.

Vienna Lime is a pure anhydrous lime, obtained from Vienna, and is extensively used where the red color of rouge is objectionable. It must be used while slacking or it is of no value, so the custom has been to mix it with oil, wax, etc., in small batches, and keep the supply in the air tight tin or bottle in which it is received from the dealer. Even then, great waste has attended its use on account of air slacking. Lately, however, several manufacturers have succeeded in making suitable compositions of Vienna lime and pressing them into cakes, which are dipped in melted parafine and wrapped in parafined paper. Thus prepared, the lime holds its polishing properties for several months, and these cakes, under various names, are meeting with considerable favor for buffing nickel, silver and other metals which it is desirable to keep white.

Brushes. After the work is colored it is necessary to wash off the oil, grease and polished material which still remains on it. This is done with brushes. The

brushes for large work are made of tampico, mounted on polishing heads and kept wet with water. Small work is cleaned with bristle brushes, which are carefully selected so as not to injure the polish on soft metal.

The work is then dipped in hot caustic potash, then in hot water, scoured well, rinsed and hung in the bath.

Pumice Stone is used in powder for scouring the work, to remove all traces of oil, grease, lye, etc., just before hanging the work in the plating solution; also in lumps, for scouring spots that refuse to take the plating, which is a comman fault in replating old trays, baskets, etc., that have been badly corroded.

It is customary to have a large sink, lined with lead, deep enough to receive all drips and rinsing water, and to hold the rinsing water, pans, brushes, pumice stone, etc., and to do the scouring on boards placed over or in the sinks, so as to catch all waste, rinsing water, dirt from the buffs and polishing powder which is washed from the work. In large establishments, where much silver and gold work is done, this sink is placed on top of a deep waste tank into which the sink discharges all waste water; the waste tank discharges from a pipe near the top at the end opposite to that from which the discharge enters from the sink, so that the dirt, which is

rich in metal, may have time to sink to the bottom before the water finds its way out of the tank. This tank is cleaned occasionally, and the dirt taken from it is dried and sent to the refiner. The dirt varies greatly in value (from $20 to $120 per barrel) according to the nature of the work done in the shop. Shops using the cheaper metals, however, rarely save their wastes in this way, as they are not worth enough.

Scratch Brushes are of two kinds,—large, heavy brushes, with coarse wire, used exclusively for cleaning castings, and smaller brushes of finer wire, used in the plating room to burnish down the layer of deposited metal when for any reason it is not taking well, or when an extremely thin and adherent coating is desired. The speed of scratch brushes is an important factor in their life and usefulness. The very best and softest brushes will crystallize and break off at the hub if the brush is run too fast. The subjoined table gives the proper speed for the various size of wires:

Wire .002 of an inch should run 1,500 revolutions per minute.
Wire .003 of an inch should run 1,200 revolutions per minute.
Wire .004 of an inch should run 1,000 revolutions per minute.
Wire .005 of an inch should run 800 revolutions per minute.
Wire .006 of an inch should run 600 revolutions per minute.
Wire .008 of an inch should run 500 revolutions per minute.

In using wire larger than .005-inch it is best to use swing brushes. These consist of an iron or wooden hub, which can be readily taken apart and new wires substituted. It is the only brush that will stand with heavy wire. A smaller size of swing brush, for mating or frosting finished work, is also much used.

In working the brush do not bear too hard against the wire. The work should be just brought in contact with the ends of the wires. If too much pressure is used you bend the wires and do not get as good results. After using the scratch brush awhile the wires will become tangled and the wheel will scour or burnish instead of cutting or matting the surface. When this is the case, simply turn the wheel the other side out on the polishing head, so that the wheel will run the other way and the wires will cut rapidly, finally straightening themselves out, and then tangle up the other way. In using soft, fine brushes in the plating room, when it is desired to matt the work, hold an old file against the brush a moment, and the ends of the wires will become bent so that they cut the work instead of burnishing. Scratch brushing in the plating room is always performed with a stream of water containing a little soap, soap root, licorice, beer or other frothy liquid trickling down upon the brush so as to keep brush and work constantly wet.

CHAPTER IV.

PREPARATION OF WORK FOR PLATING.

Much of the success or failure of plating may be traced directly to the degree of skill and care used in preparing the work before it is placed in the solution. It is not too much to say that nine-tenths of the blistering, stripping, turning yellow, and other troubles which only show after the work is done, may be traced to its improper preparation.

Iron and Steel castings, forgings, etc., are first pickled and scratch brushed or "rattled" to remove the scale if necessary, then cut down with 70 emery on a canvas wheel; then with 90 emery until all marks of the 70 emery are taken out; they are then "fined" on a 120 wheel, then "greased" with 150 emery on a grease wheel. This is followed by "dry fining" on a well worn grease wheel and then colored on a wheel glazed with pumice and a flint stone, as previously

described. This gives the finest finish and the most durable plating, if the workman has been careful in each operation to get out all marks of the previous or coarser grinding. In many cases on cheap work, the dry fining is omitted and the omission can be generally detected after the plating is done. Smoother work, such as replating, or work that has been turned up in a lathe, or otherwise machined, has one or more of the first grindings omitted, according to the circumstances and the degree of smoothness when the articles come into the polisher's hands.

Tableware, a knife, for example, is roughed out with 90 emery on a felt wheel, then with 120 emery, and then with 150 emery on a grease wheel, until all marks of the 120 emery are polished out. It is then dry fined and colored. The finishing wheels should be kept as smooth as possible in order to do the best work, as the plating will wear much longer if the steel be made perfectly smooth. After the knife is colored, it is boiled in hot potash water to remove all grease that is on the work. It is then scoured with powdered pumice stone and water, using a stiff bristle brush, until clean water will run off and show no traces of grease on the knife. A fine copper wire is then twisted on to the handle and the work dipped into a pickle of one gallon of muriatic

acid and one gallon of nitric acid with one quart of water and a handful of salt, rinsed and hung in the solution. The same general procedure is followed on all first-class steel and iron work.

Brass and Copper, if already smooth, can be polished with tripoli on a cotton buff. If rough, they may be roughed out with 120 emery, or coarse tripoli, then put on the grease wheel and then polished with rouge and finally with Vienna lime on a soft buff. They are then dipped in potash, rinsed, and then in a cyanide dip—two or three ounces to a gallon of water—rinsed in clean, cold water, brushed with powdered pumice stone, as before described, rinsed and hung in the solution.

Zinc is roughened with fine emery and polished with Vienna lime and oil. Britannia metal or lead must not be left in the potash too long, or it is liable to eat out the lead and tin; the best way is to brush the work thoroughly with the potash water instead of dipping it; then scour with pumice stone.

Lead, Tin and Brittania are polished on a walrus wheel with pumice stone. The pumice is mixed with a little oil to make it hold together. A little of this is

then placed on the work and it is held lightly against the wheel. Do not press hard on the work, or it will cut holes in the metal instead of polishing. After polishing it is then scoured with pumice as before, to remove all oil, and rinsed, then plated. Large silver trays are polished by hand with lump pumice stone and water. After all the fine holes are taken out in this way, a Scotch stone and water are used until all marks of the pumice are removed. It is then buffed with a seahorse wheel and pumice (as described for lead), then with hard rouge, and finally colored with soft rouge and alcohol. In this way a large flat surface can be made very smooth.

When the operations described above have been thoroughly carried out, the work will generally take a very firm and adhesive coat of metal if ordinary care is taken in plating with copper, brass, silver or gold, but nickel may give some trouble if deposited directly upon the object, especially if it be steel.

CHAPTER V.

THE ACTION OF DIPS AND PICKLES.

While the best polish is secured by grinding and polishing on a wheel, many articles will not admit of this, either from their nature or form, or because it would be too expensive to treat them in this manner. Such articles are therefore cleaned chemically, by immersing them in solutions which dissolve the scale, grease, etc., adhering to them, and leave a clean but more or less rough surface which has to be smoothed afterwards. Those solutions which are intended for prolonged action on rough work are called pickles, and those which are intended for an instantaneous action on a surface already smooth are called dips. There is little difference between their action, except that the dips are intended to secure uniform action on the surface of the work, which is accomplished by using strong acids with little or no water, while pickles usually contain a large proportion of water and depend upon continued

action, often accompanied with vigorous brushing to throw off the scale.

Generally speaking, success in using the various pickles and dips depends chiefly upon quick and careful handling, rather than upon the dips themselves, the main points in using the latter being to secure perfect cleanliness of the work (without which uniform action is impossible), and to see that little or no water is carried into the dip. This is secured by dipping the work in boiling lye and then rinsing in boiling water, shaking a moment to drive off the water and then immersing in the dip. Large numbers of small articles, strung on copper wire, may be handled in this way with great speed, the heat drying them almost immediately. If the work comes from the dip smooth, but of uneven color, you can make up your mind the work is not clean; if the color is even or nearly so, but is pitted or roughened in places, the trouble is water in your dip. In using bright dips, and also in using oxidizing dips while finishing work, the time the work remains in the solution has an important influence upon the result; in many cases a number of colors or surfaces may be produced by one dip, simply by altering the time the work is allowed to remain in the dip.

Black Pickle for Iron is made by mixing in a stone jar or tank, according to quantity

Sulphuric acid 66° B.....1 part.
Water.....15 parts.

Hydrochloric acid may be substituted for the sulphuric if desired. This is used chiefly for removing scale from castings and forgings.

Bright Pickle for Iron. A pickle which leaves the metal bright is made by mixing slowly *in the order named:*

Water.....10 quarts.
Concentrated sulphuric acid.....28 ozs.
Zinc .....2 ozs.
Nitric acid .....12 ozs.

Pickle for Copper, Brass, Etc. Forgings, punchings, etc., are pickled in dilute sulphuric acid to remove scale, and then cleaned and brightened by dipping in a solution made up as follows:

Sulphuric acid 66° B.....50 parts by weight.
Nitric acid 36° B.....100 parts by weight.
Common salt.....1 part by weight.
Lamp black.....1 part by weight.

After dipping and rinsing in hot water the work is ready for polishing and coloring.

Bright Dip for Copper or Brass. Copper or Brass work that is not to be buffed or polished is best dipped first in a pickle of

Nitric acid 36° B.	200 parts by weight.
Common salt	1 part by weight.
Lamp black	2 parts by weight.

After pickling until clean, they are thoroughly rinsed in boiling water, allowed to dry a moment and plunged into a "bright dip" of

Nitric acid 40° B.	75 parts by weight.
Sulphuric acid 66° B.	100 parts by weight.
Common salt	1 part by weight.

Cyanide Dip for Brass. Potassium cyanide in ten times its weight of water is used as a preliminary dip when plating articles that would have the polish injured by the acid dips. The work must be allowed to remain longer in this than in the acids.

Pickle for German Silver. German silver may be cleaned in the bright dip for brass, or in a preliminary pickle of dilute nitric acid and water (12 to 1), followed by a dip of equal parts of sulphuric and nitric acids, and then by rinsing in boiling water and drying in sawdust. Use sawdust that contains no tannin.

Pickles for Gold Alloys. While properly belonging to the goldsmiths' art, it may occasionally be useful to the plater to know how such pickling is done, as it often saves much time in coloring new work.

The methods given are distinctly inferior to "running off the green," as detailed in the chapter on stripping, but may occasionally prove useful on some kinds of work, or in saving time where it is desired to remove as much as possible of the coating before putting in the bath for removing the green.

Gold alloys, especially those containing copper, assume an unsightly, dark brown exterior, owing to the copper oxide generated by the repeated glow-heating during work. In order to remove this the object must be pickled, and either highly diluted sulphuric or nitric acid is used, according to the color desired.

If working with an alloy consisting only of gold and copper, either sulphuric or nitric acid may be used indefinitely, since gold is not attacked by either of these acids, while copper oxide is easily decomposed thereby, and after having been pickled, the article will assume the color of pure gold, because its surface is covered with a layer of the pure metal.

If the alloy is composed of pure gold and silver, however, only nitric acid can be employed, and the article is

left immersed in it only for a short time; this acid dissolves a very small portion of the silver, and the article also assumes the color of pure gold.

When working with an alloy which, besides the gold, contains both copper and silver, the process of pickling may be varied in accordance with the color desired to be given to the article. If the pickling is performed in sulphuric acid, the copper alone is dissolved, the article assuming a color corresponding to a gold-silver alloy, which now constitutes the surface of the article.

If nitric acid is used, it will dissolve the silver as well as copper, and in this case a pure gold color is produced.

Pickling is done by first feebly glow-heating the article and cooling it; this operation is for the purpose of destroying any fat from the hands or other contamination adhering to the article. If it was soldered with some easy flowing solder, this glow-heating must be omitted, but it may be cleansed from impurities by immersing it at first into very strong caustic lye, and rinsing it with water; it is then laid into the acid.

The acids are employed in a dilute state, taking 40 parts water to 1 part concentrated sulphuric or nitric acid. If more articles than one, they had best be laid

beside each other in a porcelain or stoneware dish, the diluted acid is poured over them, and some article is lifted out from time to time to watch the course of proceedings, whether it has assumed a yellow color.

When to satisfaction, they are rinsed with clean water and dried. While pickling for the purpose only of causing the color peculiar to gold to appear, the process of coloring has for its object to lend the appearance of very fine gold to an article of an indifferent alloy. Various mixtures may be employed for the purpose, and we give two recipes below which are very appropriate:

Mix 2 parts saltpeter, 1 part table salt and 6 parts alum, with 6½ parts water, and place in a porcelain dish for heating. As soon as you notice that the mixture begins to rise, add 1 part of muriatic acid, raise the whole to boiling and stir with a glass rod.

The article to be colored, and previously treated with sulphuric acid, as specified, is suspended to a hook either of sufficiently thick platinum wire or glass; it is then introduced into the rather slow boiling bath, and moved around in it. It is to be taken out in about three minutes, and rinsed in clean water, inspecting its color at the same time. If not to satisfaction, it is returned to the bath, and this withdrawing or reintroducing is

repeated until the desired color is obtained. By the latter immersions the article is left only one minute at a time in the fluid.

When sufficiently colored, the article after rinsing, will be of a high yellow and matt color; it is washed repeatedly in water to remove the last traces of the bath, and then dried in hot sawdust.

In place of drying in sawdust the article may also be dipped in boiling water, leaving it in for a few seconds; the adhering water will evaporate almost instantaneously when the article is withdrawn.

The second coloring method consists in pouring water over a mixture of 115 parts table salt and 230 nitric acid, so that the salt is dissolved; it is then to be heated until a dry salt residue is again present. This residue is mixed with 172 parts fuming muriatic acid and heated to boiling, for which purpose a porcelain vessel is to be used.

As soon as the pungent odor of chlorine gas begins to evolve, the article to be colored is immersed, and left for about eight minutes in the fluid for the first time; in other respects a similar treatment, as specified above, is also used for this method; if the article colored was polished previously, a subsequent polishing is unnecessary. On account of the vapors evolved by the coloring

baths, which are dangerous to health, the operations should be performed either under a well-drawing flue, or what is still better, in open air.

Always keep the various pickles, dips, etc., for the various metals separate from each other. A simple and effective way is to mark the bottles, jars, etc., containing them, with asphaltum varnish, as it will withstand acids.

CHAPTER VI.

THE USE OF STRIPPING SOLUTIONS.

It frequently happens that a coating of metal on the surface of an object must be removed, either from existing imperfections in new work or an old and partially worn coating on work that has been brought in to be replated. To grind off such a coating is slow, tedious and expensive, as the several operations of cutting down, polishing and coloring must be proceeded with as if the piece were new and the amount of metal, if it be silver or gold, is also worth saving. To plate such work without removing the old deposit makes in most cases a spotty and uneven job, as the metal deposits much more readily on the old coating than on the bare places, where it is most needed.

The proper course in such cases is to strip, or dissolve off the metal from the article, leaving it free and clean, so that good, uniform and adherent plating may be done without the expense alluded to above.

Such solutions are compounded for use in two ways, without a battery and with one. The first may be regarded as "dips," as they are of the same nature and used in the same way, except that the articles remain in the solution for a longer time.

The second class is compounded much as a plating solution would be if it were intended to be used with a strong current; that is they are compounded with a great excess of cyanide and strong alkalies, with a little cheap metal in them, and they are invariably used with a very strong current of great quantity. The articles to be stripped are run as anodes, with a copper, carbon or platinum strip used as a cathode. In running work as anodes there are certain conditions which make all the difference between success and failure. Hanging the work in such a bath and allowing it to remain quiet, with a moderate current, will simply strip the work, leaving it clean but rough; if a strong current be used and the work is hung in the ordinary way, the article will be stripped, but the surface will be blackened and need repolishing; if the articles be suspended by wires so as not to touch each other and *kept constantly in motion* and the current be frequently *interrupted*, the articles will come out of the solution bright, smooth, and ready to color. The work should be immediately rinsed in hot

water and rapidly dried. The wash water may be saved and used in keeping up the stripping solution. The great utility of such solutions will be at once perceived, as the saving of expense in refinishing old work and the proper cleaning up of many kinds of new jewelry, etc., is extremely important and frequently has even more influence upon the plater's reputation as a prompt and skillful workman than it does upon his pocket book.

Stripping Nickel. Take a stout stone jar which has a cover and place it where the fumes may escape when it is being used. Place in it the following mixture, adding the acids slowly *in the order named:*

Water	2 quarts
Sulphuric acid 66° B	16 lbs.
Nitric acid	4 lbs.

Allow the mixture to cool before adding the nitric acid. The work to be stripped is strung on copper wire and immersed in the solution. It should be watched carefully and removed and thoroughly rinsed in hot water the instant the nickel is dissolved. When properly done the work will be bright and clean.

Stripping Silver. Silver may be removed from copper or brass articles by dipping them in a mixture of

equal parts of fuming sulphuric acid and nitric acid of 40° B. The copper is not attacked, unless there is water in the mixture of acids. Care must be taken to keep the solution tightly closed (in bottles or otherwise), as it attracts water from the air if allowed to stand open.

Iron articles are run as anodes in a solution of one part of cyanide of potassium to twenty of water, with copper or silver cathodes.

Stripping Gold. Gold may be stripped from copper, silver or German silver by dipping in a mixture of

Fuming sulphuric acid	1 lb.
Hydrochloric acid (conc.)	2⅔ oz.
Nitric acid 40° B	1¼ oz.

Care must be taken to see that no water is allowed to get into the mixture, or the work will be attacked. This mixture works best while warm and the same precautions as to keeping, that have been mentioned in the silver stripping solution, are also applicable here.

Iron and steel are stripped by running as anodes in cyanide of potassium solution; about ten ounces cyanide to one gallon of water, used with copper cathode.

Stripping Oxides, or Removing the Green, as it is often called, is a process which is of great importance

in coloring new gold work and should be generally understood by the platers who desire to do really good finishing on either new or old work of low quality gold. During the various operations of manufacture, the numerous heatings for hard soldering cause a film of oxides, combined with the compounds of the flux and the baser metals in the object, to form over the surface of the article, and in many cases this coating is imperfectly removed by the subsequent pickling and polishing it receives. If the article be colored without removing this coating entirely, it will work through after it has been a short time in use and the purchaser thinks he has been swindled. This causes trouble all along the line, to retailer, jobber and manufacturer. It is particularly prominent with roll plate chains and next to that in rings of 6k to 14k quality. Articles of this nature, therefore, should be run as anodes in a solution of

Carbonate of copper.....4 ozs.
Carbonate of soda.....8 ozs.
FFFF ammonia.....8 ozs.
Water.....2 gallons.
Cyanide of potassium until 16° B. is shown.

The work is run as anodes in this solution, using a strong current and copper cathodes and keeping the work continually in motion, as described in the beginning

of this chapter. Properly done, the work will come out bright and smooth. An old solution will work better than a new one, hence it should not be thrown away, but saved and added to from time to time. Care should be taken to keep the solution at about 16° B.; under 10° B. or over 20° B. it will not do good work.

This solution will be found very useful in cleaning up brass or other articles which have become tarnished, also in cleaning chains, etc., to be replated as well as for finishing new jewelry.

CHAPTER VII.

QUICKENING SOLUTIONS FOR CHEAP WORK.

It sometimes happens that the plater is called upon to give a very thin and cheap coating of silver upon articles which, from their nature and the metal of which they are composed, cannot be polished and prepared for plating in the ordinary way; we refer to such articles as photograph frames in thin, perforated designs, cast from a mixture of tin, lead and antimony or zinc (lead predominating in the mixture), trays and various other shapes of the metal, all classed by dealers as "Novelties." These goods are generally brought to the plater as soon as cast and must be plated immediately for next to nothing.

Such goods are strung on wires, dipped into hot water, then into a hot quickening solution, composed of a strong solution of corrosive sublimate (bichlorate of mercury) and salammoniac, which leaves a very thin film of mercury on the article; it is then transferred to

a silver solution low in silver and strong in cyanide, kept in it a moment, rinsed in hot water and dried and lacquered immediately. The whole operation must be performed rapidly and the work kept constantly in motion while in the solutions. The entire process ought not to occupy over two minutes. Of course such work cannot stand inspection; it is not intended to. Cheapness and speed are the sole requirements. When doing such jobs, the plater must insist that the work be lacquered immediately; it will discolor if allowed to stand three or four hours without lacquer.

Another quickening solution, frequently used on work composed of one of the many alloys called "German silver" by the various hollow ware concerns, consists of a weak solution of potassium-mercury cyanide in water. A weak solution of acidulated nitrate of mercury is also frequently used on work of this class.

These solutions are often useful in replating old work which has a tendency to refuse to plate in spots that have been badly corroded. There is no special rule to be observed in regard to strength; the object is simply to coat with mercury spots that will not plate without it and the less mercury employed to amalgamate the surface the better for the work. Such solutions should be employed just before the work is put into the plating

bath and they should always be followed by hot rinsing and the work never allowed to dry.

Always keep the quickening solutions for the various metals separate from each other. Covered ten or twenty gallon stone jars are generally used to hold such solutions.

CHAPTER VIII.

COPPER AND BRASS BATHS.

Perhaps the most useful solutions for the man who does plating in either a large or small way, are the cyanide copper solution and the cyanide brass or bronze solution. The acid copper solution often used, which is merely sulphate of copper dissolved in water, is easily made and used, but has numerous disadvantages when compared with the cyanide. It will deposit faster, but leaves a rough and crystalline surface, unless used with current of very low tension, and cannot be used on steel, as the latter metal is electrically opposed to copper in the presence of sulphuric acid, and sets up a local action which throws off the deposit in scales as fast as it is formed.

The cyanide copper solution, on the other hand, deposits a smooth, even and firm coating, takes equally well on steel as on brass or other surfaces, and is capable of so many variations that it may well be

regarded as the basis of all brass, bronze and copper plating. In addition to this, it is the only sure means of making a firm deposit of silver or gold on steel. Articles of iron or steel should first be given a coating of copper, and then the gold or nickel will be held firmly, evenly and smoothly, so that lighter coatings of the more expensive metals wear longer and look better than a thicker deposit directly on the steel.

The old formulae for cyanide of copper solutions all recommend mixing acetate of copper with carbonate and bisulphate of soda, and then adding potassium cyanide to the carbonate of copper thus formed. This encumbers the bath with a number of useless secondary reactions, and makes it liable to readily get out of order. It is much better to buy carbonate of copper from a dealer in platers' supplies. It is cheaper than the acetate, and does not put anything in the solution which is unnecessary.

Formula for Copper. To make the solution, use to each gallon of water:

Carbonate of copper	5 ozs.
Carbonate of potash	2 ozs.
Cyanide of potassium (chemically pure)	10 ozs.

Dissolve about nine-tenths of the cyanide of potassium in a portion of the water and add nearly all of the carbonate of copper, previously dissolved in a portion of the water; then add the carbonate of potash, also dissolved in water, slowly stirring until thoroughly mixed. If you have a hydrometer, make your solution to 16° B., then put in a small article and test your solution, adding cyanide or copper, or both, until the solution deposits freely and uniformly.

This may be regarded as a stock solution, and if much work is done, it is best to use it as a basis and make others from it, keeping them separate.

Brass Solutions of any desired color may be made by adding carbonate of zinc, in varying proportions, to the copper solution. This is done by dissolving about one part by weight of carbonate of zinc to two parts of cyanide of potassium in sufficient water to dissolve them and adding same slowly to the copper bath, having a piece of work in the tank at the time and noting the change of color of the deposit. One part of zinc and two of copper will give a yellow brass.

If the color is to be a light yellow brass, add a little carbonate of ammonia to the brass solution. If deposit is granular add more cyanide; if slow and dark add

more zinc. If color is too light add more copper carbonate and less current. If, however, the plater desires to match colors on repairing jobs, etc., he can get any desired color from his brass bath by varying his current; a strong current will deposit more zinc than copper, giving a paler color of brass in the deposit; and a weaker current will deposit more copper than zinc, giving a redder deposit. In this way most repair jobs can be matched in color, although it is better when doing new work to make your solution of the color desired, and use an anode of the same color, as by doing so you put the two metals into the solution in the same proportion as you are taking them out. If you are using copper anodes, it is best to buy the electrically deposited anodes from a dealer in platers' supplies, as they cost no more, are always pure, and deposit much freer and smoother than the hard rolled copper for sale at metal houses.

Management of the Bath. Those who have never used the cyanide copper and brass baths may desire some additional particulars regarding their management. The anodes in such a bath may sometimes show a slight greenish coating, consisting of copper cyanide, if the bath lacks cyanide. This is soluble in the free cyanide that is in the bath, and no traces of it should appear on

the anodes. When the cyanide is used up, this green coating thickens up rapidly, and the bath, shortly afterwards, stops depositing. In such a case, add cyanide (dissolved in water), very slowly, in order not to get in too much. When the bath is working properly there will be no traces of this green coating, but work put in the tanks should be rapidly covered with metal and this action is accompanied by considerable evolution of gas, which forms a froth over the surface of the solution, if the tank is full of work.

If too much cyanide is in the bath, bubbles of hydrogen will come from the objects to be coated, but no copper will be deposited, and the remedy is adding carbonate of copper, dissolved in water with a little cyanide.

If either of the above does not give a rapid and even coating, the bath needs more metal, and you are likely using too small an anode and stripping your bath. The remedy is, of course, found in adding more carbonate and using a larger anode.

Any jobbing plater who will make up copper and brass baths as above, and work them a little while, will not be willing to discard them for anything now known to the trade, as in simplicity and ease of working, and variety of color, they excel everything else in use.

Heavy Coppering. For coppering before nickeling, however, the ordinary cyanide bath will not give the best results, as the deposits cannot be made thick enough to buff down smooth and solid, so that the nickel will hold as if the article were solid copper, go on smooth and bright, and stand up under hard usage. Bicycle work is probably the hardest test of nickeling in use to-day, and next to that comes watchmakers' tools, especially lathes. All manufacturers now concede that steel work should be coppered before nickeling, and while there are many methods of copper plating, there is only one way to treat work that is subjected to much wear, if you wish the best results.

A "strike" solution is of no special benefit and does not improve your plating; a slightly heavier deposit, that will not stand buffing, is hardly any better, as unless great care is taken in scrubbing, the nickel will peel off in spots, sometimes taking the copper with it. This method also requires a very heavy coat of nickel, for when it goes to the buffer it requires a great deal of cutting down before a good lustre can be obtained. The best results can only be had by depositing a very heavy coat of copper, so that the copper can be buffed bright without the steel showing through, and recleaned with lime or whiting and a soft bristle brush. By adopting

this method of coppering, the work, with a moderate current, will stand from two to three hours in the nickel bath, and in buffing, a beautiful lustre is obtained without the use of any cutting-down materials. In buffing copper deposited on steel, the rough points, edges or corners that the polishing wheel may have left, are rounded off, consequently the final nickel buffing requires only a slight pressure to bring out a beautiful color.

This method of handling the copper plating is not difficult, but it requires close attention, and a copper solution built up to suit this work. The copper solution should be rich in cyanide, and have just enough copper to give a free deposit. To make the solution, fill your tank about two-thirds full of water; then dissolve in a separate vessel 10 ounces of C. P. cyanide to each gallon of solution you intend to make, and when dissolved, add to the water in the tank and stir; in another vessel dissolve 5 ounces per gallon of pure carbonate of copper. This should preferably be of the moist form, but if the moist is not procurable the dry will do. Care must be used in either case to see that the copper is thoroughly dissolved in the water before adding it to the solution. Then add the dissolved carbonate to the cyanide in the tank, and stir until it is all taken up.

Finally add 2 ounces of carbonate of potash for each gallon of solution, dissolved separately or not, but preferably the former. Then make your connections to the dynamo, put in anodes and a piece of work, and try it. Possibly there will be no deposit, but emission of gas instead, or a very slow deposit. In this case dissolve more carbonate of copper, and add it to the solution slowly, until a good deposit is obtained. Should the work blister, and you have a strong current on, reduce the current; if you still have trouble, add more cyanide. The solution should stand at 12° to 15° Baume, and the above formula is calculated to bring it nearly there at the start. Such a solution has been made and got in good running order in two hours, so that any plater should have no trouble at all in starting it.

For anodes you should use the electrolytic or deposited copper plates, as they give off copper more freely than the rolled plates and keep the solution in better condition. The current from the dynamos should be rather weak, and must be regulated to suit the amount of work in the tanks, which can best be done by having a separate switchboard for every tank.

Let your work hang in the copper tank for thirty minutes; should it blister, add more cyanide, reduce the

current, and repeat until the difficulty is overcome. When the conditions are right, work can be left in the copper solution for several hours without showing the least signs of blistering.

Any number of brass and bronze baths may be made in this way by dissolving salts of the metals in the required proportions with cyanide and water. The salts taken are generally the carbonates, as carbonic acid is the the weakest and is therefore displaced by the cyanide with less loss by secondary reactions, as carbonate of potassium may be easily destroyed in the bath by adding a little hydrocyanic acid, which drives off the carbonic acid in bubbles and leaves the bath quite clean and free from secondary reactions, far more so at least than can be done when using salts from stronger acids. The result is therefore the formation of cyanides of the metal in combination with the double cyanides of the metal and potassium. Eventually the single salts become double salts and then the bath is in smooth working order. This is the reason that old baths work better than new ones. If a bath were to be made from the double cyanide of potassium and any other metal it should work well at the beginning, but this is too expensive; so the plater makes the cyanide of the metal by dissolving the carbonate with cyanide of

potassium, adds free cyanide to the bath, and thus forms the desired salt while working.

In working baths of mixed metals the intensity of the current is important, as well as the quantity, and the use of measuring instruments is recommended, especially to the plater who is working combinations that are new to him.

CHAPTER IX.

NICKEL PLATING SOLUTIONS.

Perhaps, of all the solutions in use today, those of nickel have undergone the most changes. The writer has in his possession seventeen formulæ, some of which are very complex in their working and could not be guaranteed to remain constant for twenty-four hours, if used with a modern dynamo and large anodes. To a chemist these formulæ are very interesting, as they contain the chemical history of the progress in working the metal; but to a workman they are very misleading, consisting as they do, chiefly of exploded notions conceived when batteries, equally unreliable, formed the only source of current, and expert dodging to favor the battery often constituted the entire sum of the operator's knowledge. Gradually, however, the citrates, chlorides, tartrates, phosphates, pyrophosphates, nitrates, etc., have been eliminated and the only bath now in use is the double sulphate of nickel and ammonium,

with perhaps the addition of a little boracic acid under certain circumstances.

The Solution. The double salt should be purchased of a dealer in platers' supplies and care should be taken to get it pure and to use as pure water as possible. The salt is dissolved by boiling 12 to 14 ounces of the salts per gallon of water in a stone jar which has never been used for anything else, and filling up the bath with water until a hydrometer placed in it stands at 6½° B. to 7° B. This is the method followed for a small bath. For a large bath this operation would take a couple of days and is not to be thought of, on account of the stoppage of the work for so long a time. Large baths are made by attaching a hose to a live steam pipe and putting a pipe with a steam valve on it on the other end of the hose, so that the steam may be readily controlled. Fill your vat about half full of cold water. Then take a large stone jar, perfectly clean, and large enough to hold several gallons; put a large quantity of double sulphate into the jar, filling it perhaps half-full; then add some cold water. Next turn on the steam, open the valve and allow the live steam to blow through a little to take out all dirt, oil, etc., that may be in the pipe; then shut the steam off, put the pipe in the jar

and open the valve slightly, so that the steam enters and dissolves the salt, which it does very rapidly. Dip out the heavy solution as fast as it fills the jar and add it to the water in the tank, stirring vigorously after each addition of salt, until the solution stands at 6½° B. to 7° B. A workman can dissolve a hundred pounds of salt and get a large solution ready in an hour in this way, when it would take all day, or even longer, to boil and make the solution as first described.

Anodes. Now, as to the anodes. They are especially important in nickel solutions, because the solution does not readily dissolve the metal, and this action takes place only under the influence of the current. Nickel sulphate is not a good conductor of electricity; ammonium sulphate is a good conductor of the current, but exercises no dissolving action upon the anodes. The double salt, therefore, is used to combine the two qualities desired, and the free sulphuric acid, liberated by the deposition, immediately passes to the opposite pole, and attacks the anodes; but the union between the nickel and the acid, in the nickel sulphate, is sufficiently complete, so that there is not enough acid left to attack a strip of metal suspended in it, without the action of the current. If we think over this action and its conse-

quences, therefore, it will be seen at once that the anodes may be left in the solution when no work is being done, and this is the general practice, as it saves handling the anodes. It is also evident that a large anode surface must be maintained to avoid stripping the solution and that cast anodes are preferable, because rolled anodes are harder and require more current power to drive the metal from them into the solution. Continuing, we also discover that the anodes should be long enough to reach to or beyond the bottom of the work, in order to insure good edges; and further, if the anode surface is too large and a strong current is used, the bath is apt to be rendered alkaline through a partial withdrawal of the acid from the ammonium portion of the double sulphate. Also, we find that the exclusive use of rolled anodes is likely to render the bath strongly acid, by robbing the bath of its metal and leaving the acid. For these reasons some platers prefer to use rolled anodes at the ends of the rods, where the current action is strongest, with cast anodes in the middle, where it is weaker. This practice, however, is being gradually given up, as with dynamo current the action is more uniform. Rolled anodes are often used for small solutions of one or two gallons, as it is easier to get them in small sizes.

The most suitable distance of the anodes to the objects to be plated is from 3½ to 6 inches; nearer than that, the nickeling is apt to be uneven, because the metal has not had time to be evenly distributed in the solution, while farther away the resistance is increased and more power is required to deposit properly; the current is often regulated in this way when other means are lacking.

Strength of Current. Under all circumstances and with all metals, a weak current will give a slow, dense and fine grained, hard deposit, while a stronger current produces a softer and more open, or even crystalline deposit; and as nickel is naturally a brittle metal, it follows that a moderately strong current is required to avoid a brittle deposit. The most suitable current strength is 3½ to 6 volts in the bath, depending largely upon the size and nature of the work, and this is generally secured by the use of two Bunsen cells, connected for intensity, for small work and the use of a suitable dynamo for larger operations. The quantity should be from .4 to .8 ampere per 15 square inches of surface of the object to be plated. This holds good for iron, brass, steel and copper, but zinc requires about double the above current.

Condition of the Bath. A nickel bath should be slightly acid to give a suitable color in the plating. Too much acid will cause peeling, and too much alkali will darken the tone of the work. The condition of the bath in this respect can be readily told by testing with litmus paper. If too acid, and the hydrometer stands at less than 6½° B., it shows that the solution has been robbed of metal, and the remedy is to add carbonate of nickel, or sulphate of nickel (generally called single salts), by dissolving it in water and adding to the solution until the proper content of metal is obtained. If the proper amount of metal is in the solution and the bath is too acid, it may be relieved by slowly adding carbonate of ammonium dissolved in water. If the bath is alkaline and more double salt cannot be added, it may be made slightly acid with sulphuric or boracic acid, but the better way is by slowly adding double sulphate of nickel and ammonium, dissolved in water, and temporarily reducing the anode surface, if the circumstances will allow of it.

Appearance of the Bath, Anodes and Work. The following signs will enable the workman to tell whether his current is right, just as the hydrometer and litmus paper will tell the state of the solution. Having

a slightly acid bath, the objects to be plated should be coated thinly with nickel, in two, or at most, three minutes, without much gas rising from them. Small bubbles coming slowly and regularly indicate regular action. If the objects throw out a great number of gas bubbles and are instantly covered with a white, thick deposit, which soon changes to a dull gray, especially around the edges and points or corners, the current is too strong, and must be reduced by putting more work in the bath or shutting off current. This depositing white and then turning gray and finally black is called burning the work. If the current is too strong, though not enough so to burn the work, the nickel will peel or blister after the objects get into use, or in aggravated cases they will not stand buffing.

If there is no deposit on the objects in three minutes, and they gradually discolor, turning darker, the current is too weak, and more current must be put on, or less work be put in the bath. It is a pious idea in such cases to make a vigorous search for short circuits. The writer could, if he were disposed, give some very amusing instances of such happenings, in shops where things are allowed to hang or lie on the conductors. Such cases often arise where the workman has neglected to keep things clean. The drippings of the

solution foul the rods as the work is taken out of the bath, and this interferes with the current in a marked degree. The hooks for anodes and work and the rods on which they hang should be kept clean and bright, by scouring with fine emery paper.

Sometimes this trouble is caused by dirty anodes. When the current is insufficient to drive the metal rapidly into the solution, a dark coating of oxides gathers on the anodes, very similar to that which forms on the zinc in some forms of primary battery. This must be removed by taking out the anode and dipping it in water and scratching or scraping it off with an old file, cold chisel, or anything of that nature. Keep anodes clean.

The same trouble sometimes arises when the anode surface is so small that not enough current can pass into the solution. This is the usual result of a mistaken idea on the part of the proprietor or foreman, who refuses to buy anodes until every scrap of nickel about the place has been used up. It is better to sell the worn anodes as scrap than to attempt to use them in this way, as the loss will be less than that caused by trouble in the plating.

The current is known to be right, and the deposit is gray, or streaked, or spotted: The bath is alkaline, or

has too much metal in it, or too little metal, or contains copper. Get your litmus paper and hydrometer.

If the bath is right and the current is right and the same defects appear, the work has not been properly cleaned, or has been allowed to dry after cleaning, or has been handled with dry or greasy hands after cleaning, so that a trace of grease on the work was turned into a waxy gum by the acid of the solution. *Absolute cleanliness* of the work *must* be maintained in nickel plating.

The deposit is white, but peels under the buff, or can be scratched off with the thumb nail: Current too strong or bath too acid.

The work is full of small holes, but the deposit is otherwise good: There was a coating of dust on the surface of the bath which you neglected to skim off, and which stuck to the work when it was put in the bath.

When a bath gets dusty, or covered with a film of oil or benzine, smoke, soot, etc., it should be skimmed off. This is accomplished by removing all work, anodes, rods, etc., from the tank, and allowing it to stand until the film gathers on the surface of the solution; then take a sheet of tissue paper by two corners, letting the sheet hang vertically, and slowly drop its lower edge on the solution at one end of the tank, letting the sheet come

down and float on the surface of the solution for about half the width of the sheet. Then draw the sheet slowly and evenly along to the other end of the tank, and allow the balance of the sheet to settle on the solution, when, after standing a moment, it may be removed and thrown away, taking with it the grease and dust. Repeat the operation until the surface remains clean. A surprising amount of oil, etc., is sometimes removed from a solution in this way.

Large spots remain uncoated: The pieces of work were allowed to touch each other in the bath, or the work was not turned about so as to get the air out of all hollows and roughnesses in the work.

The work is coated nicely near the anodes but not on the portions further away: The current was too weak, or the conducting power of the bath was poor. Sometimes the spots covered by the hanging wires will not be covered in aggravated cases of this kind. Flat objects should be suspended between two rows of anodes; round objects, or those of irregular shapes, should have the anodes placed about them as nearly equidistant as possible.

Doctoring such spotted work is done by removing it from the bath and scratch brushing thoroughly, without allowing the work to become dry; or, if it cannot be

scratch brushed, scouring with pumice and cleaning thoroughly will do as well; then return the work to the solution.

With things working correctly, the work will take a white, even deposit, which will gradually thicken until a dull, bluish luster appears and the work does not take a further regular deposit, unless removed from the bath and scratch brushed. If allowed to remain in the bath without scratch brushing after the color turns into a bluish luster, any further deposit is of a dull gray; all the metal deposited after this occurs must then be polished away to get a bright finish.

Long Objects, hung vertically, should be turned after being coated about half the desired thickness, as the nickeling is always heavier at the bottom of a deep solution. For this reason it is better to hang the work with its greatest dimensions lengthwise of the tank when possible.

The Temperature of the solution is a frequent cause of trouble in country shops, and some in cities, also, if no provision is made for keeping them warm over night in cold weather. The amount of nickel salts that water will dissolve and hold in solution, depends largely

upon its temperature; the hotter the water, the more salt it will hold. If the bath is allowed to go below 60° F., a portion of the salt will crystallize, and be found at the bottom of the tank and on the anodes, thus robbing it of its metal and making bad work until it is redissolved.

Density of the Solution. Sometimes the sclution becomes too dense, on account of the constant removal of water, which adheres to the work that is taken out, so that crystallization of the nickel salt occurs on the anodes. When this occurs, take out the anodes and dip them in hot water until the salt is dissolved; then return them to their places and add the water to the solution, thus saving the salt and reducing the density of the solution to its proper standard.

Sometimes, when baths are being worked very hard the plan of hanging bags of double sulphate salts to the rods over night is adopted. This is a simple and easy way of refreshing a solution that is being constantly robbed, as the salt has all night to dissolve.

Boracic Acid. We have previously mentioned the use of boracic acid. This is sometimes of value when the solution becomes muddy and dense, from becoming alkaline, so that the deposit is no longer white and

tough. The acid is then used in the proportion of about two ounces to the gallon of solution, and has the effect of clearing up the solution and whitening the deposit. It is useful under some circumstances, although baths have been run for years with only the occasional addition of double salts, and many platers running large plants never use anything but single and double sulphate of nickel in their baths.

Thick Deposits. With a bath and current properly regulated, work may be left in the tank as long as desired and a coating of any desired thickness may be produced, if occasionally removed and scratch brushed when extra heavy deposits are required.

Dead Finish. Objects which are not to be polished but left dead white, should be rinsed very thoroughly in boiling water, then swung in the air, to throw off as much water as possible, and allowed to dry spontaneously, and as dead nickel is very readily soiled, it should be handled as little as possible.

Polishing is done with felt or cotton buffs, with a little rouge, and then with Vienna lime, using very light pressure on the work, and 2,500 to 3,500 revolutions of

the buffs. The cleaning after polishing is done with hot soapsuds and brush, or hot, weak lye, and a thorough rinsing in very hot water, so that the work may be hot enough to dry itself immediately, if large; or, if small, it is thrown into hot sawdust to dry, and then brushed out with a soft brush.

Black Nickel Plating. Black nickel is, by most platers, supposed to be produced by nickeling in the ordinary way and then dipping in one of the many solutions which give a black color, and afterwards lacquering. Others dissolve steel filings to the point of saturation in hydrochloric acid, and then add one ounce of arsenic to the gallon of solution thus formed, and then deposit the iron upon the previously nickeled work, finishing with lacquer. Another way frequently practiced is, to take a quantity of carbonate of copper and dissolve it in a portion of the regular nickel solution, and add a little arsenious acid. As usually practiced, however, these methods are more costly and inferior in results to an ordinary black dip.

It is possible, however, to deposit a coating of nickel which shall be of a deep velvety black and equally hard, durable and as thick as the ordinary good nickel plating turned out in the best shops of today. Believing that

this formula, which I have never seen published, may be of considerable use, I give it in full. For each gallon of solution desired, take:

Double sulphate of nickel and ammonia	12 ozs.
FFFF Aqua ammonia	16 "
Carbonate of ammonia	2 "
Arsenic	2 "
Cyanide of potassium, C. P	q. s.
Water to make one gallon.	

If properly handled this solution is easily made, but unless certain methods are followed it can only be made with difficulty, if at all. The black color of the deposit is due solely to the arsenic, aided a little by the great excess of alkali in the bath. If you get in plenty of arsenic you will have a fine velvety black; if less arsenic is used the color is brownish, and if little is used, the deposit will be powdery and will not adhere.

To Dissolve Arsenic. Arsenic is dissolved in cold water with great difficulty (about one part of arsenic to eighty of cold water in the course of a week) so we see at once that here is our trouble. Arsenic will dissolve one part to twenty of water by boiling some hours; this is, of course, impracticable also, but it furnishes a hint. Certain salts, naturally insoluble in water, are readily

soluble with the carbonates of the alkaline metals, as carbonate of sodium, carbonate of potassium, carbonate of ammonium, etc., and as we are going to have ammonia in our solution, we take the latter salt in preference to the others for our solvent for the arsenic. Again, all hot solutions will hold more than cold ones, and the stronger our carbonate of ammonia solution is, the more arsenic may be dissolved in it. Therefore, we shall get along much better by dissolving our arsenic and carbonate of ammonia by boiling in a very little water than we would if we took more of it.

I have been thus particular on this point because the use of arsenic is often recommended in various solutions which have a tendency to give coarse or granular deposits, and its proper introduction into a solution is a point that I have never seen explained in any of the many works on plating which I have examined. Many pounds of it have been put into various solutions only to lie as mud on the bottom of the tank, because the person who recommended it to a plater in difficulty either did not know or did not take the trouble to tell him how to get it into the solution so that it would stay there. And what is true of arsenic is also true of many other insoluble salts in more or less frequent use in plating. It may be stated as a rule that an insoluble or sparingly

soluble salt may be readily dissolved by combining it with another salt more readily dissolved and not antagonistic to the solution, thus forming a double salt, which easily dissolves and gives little or no trouble. It is usual to select the carbonates for this purpose because they are more readily attacked by other acids or alkalies, carbonic acid being the weakest of the acids and forming weaker combinations with other elements.

Making up the Solution. This carbonate of ammonia should be powdered and mixed with the arsenic and the two put into a glass bottle and put into a sand bath (or the bottle may be put into a water bath if the quantity is so great that a large bottle is required to hold it), then a little water is added and the whole is heated. The carbonate of ammonia dissolves first and then dissolves the arsenic. If the carbonate is not all dissolved, more water must be added. If the carbonate is all dissolved, and after heating for some time some of the arsenic still lies on the bottom, more carbonate should be added slowly until the arsenic is all dissolved. In this way it is possible to get very strong solutions of the insoluble salts.

The nickel salt may also be dissolved separately in some more of the water, at the same time, to hasten

matters, and when both are ready, put the remainder of the water in the tank or jar and add the nickel and arsenic solutions and finally the amonia, stirring thoroughly. When the stirring is completed, the clear green of the nickel solution will have turned to a milky, reddish blue, or lavender color, and after waiting until the color is uniform, we start to clear it by adding cyanide of potassium. This should be done slowly, stopping before the solution is perfectly clear and colorless, as the changes take place slowly if it is a large solution (say 200 or 300 gallons), and if we clear up at once we are liable to get in too much cyanide, which would of coarse interfere with the deposits the same way that it does with other nickel solutions.

When the solution is clear, or nearly so, it is ready for the work, which is prepared in the same way as for ordinary plating and hung in the bath with nickel anodes, using a little weaker current then when plating for bright work. A little experimenting will soon determine the proper current strength.

The arsenic gives the black color and firmness to the deposit. It is not used up, but remains in the bath a long time, sometimes lasting six months or a year without replenishing. In all other respects the bath is handled like an ordinary nickel bath.

The Deposit should take place rapidly and evenly, a sufficient deposit to color being obtained in three or four minutes, and if only coloring is desired it should then be removed, coming out of the bath a dull black, which polishes well and is easily cut through with the buff for a "cut through" finish. Leaving the work longer in the bath will give a hard, even, durable finish, excellently adapted for many purposes, and greatly superior in color and wearing qualities to any dips or other methods now in common use, and at no greater cost than that of ordinary bright nickel plating.

CHAPTER X.

SILVER PLATING BATHS.

Chloride of silver, dissolved in cyanide of potassium, has long been the standard silver-plating bath. This is so from two causes: One is that the use of electro-plated ware in silver has been so much more extensive than that of any other metal that more attention was paid to the solutions, and they were simplified, while the formulæ for other baths were neglected; the other is found in the readily workable nature of the metal, which combines easily with the other elements.

The old formulæ all told the workman to start with the silver and make his baths from the metal, but it is no longer advisable to do so, as the process is tedious and troublesome, and will cost him more than it will to buy the chloride, with the additional disadvantage of having impurities in his bath if he attempts to work up old silver, as he probably will. Still, for the information of those who desire to know the process, we will give it.

To Make Chloride of Silver. Take a wide-mouthed two-quart bottle, with glass stopper, the kind called "salt mouths" by druggists, and place in it the silver you wish to dissolve, which should be bent irregularly or cut in pieces, so as to present as much surface as possible to the action of the acid. Pour on it a quantity of dilute nitric acid, one part acid to eight of water, and place the bottle in the open air or some place where the fumes evolved may escape freely from the open mouth of the bottle without fouling the air of the room, as they are disagreeable to breathe, and will tarnish bright metal and bleach out wall paper, etc. Add the acid, a little at a time, until all the silver is dissolved, so as not to get in too much, and thus waste the acid. When this is accomplished, prepare a saturated solution of common salt (chloride of sodium) and pour it, a little at a time, into the nitrate of silver previously formed, stirring all the time with a glass rod. The nitric acid then leaves the silver and unites with the sodium, forming nitrate of sodium and freeing the chlorine, which, in turn, unites with the silver, forming chloride of silver, which gradually falls to the bottom in the form of a white powder, when the water becomes quiet. After allowing all the silver to settle to the bottom, so that the liquid above is clear, add a liltle more salted water, until

no more silver is thrown down, and again allow the powder to settle. Then take a rubber tube, and syphon off as much of the liquid as you can without disturbing the powder. Fill the jar nearly full of water, put in the glass stopper, shake the bottle thoroughly, so as to wash the nitrate of sodium out of the chloride of silver, allow the silver to settle until the water is clear, syphon as before, and repeat the process two or three times. Then dry the powder by standing the bottle in a gentle heat until the water has all evaporated. The precipitation and washing should he performed at night, or in a dim light, as chloride of silver is partially decomposed by the action of light, turning purple, and these purple sub-salts will not dissolve as readily in cyanide of potassium, thus entailing a loss of silver. It is for this reason that the workman is recommended to buy his chloride. getting a pure article, and leaving the chemical reactions to those who are better prepared to perform them. Still, with care and patience, it is not a difficult matter to make pure chloride of silver, by using pure chemicals and pure silver. If you desire to check up your results, you can do so by weighing the bottle and silver before you commence and again after the chloride is formed and dried in it, which will give you the amount of chloride of silver you have obtained. Then get your

druggist to calculate for you the amount of chloride you should have, and the difference between the actual and theoretical amounts will show the loss from impurities in the metal and the washings, etc. Still the above is useful only in working up scrap, or to the experimentalist, etc.

The Solution for plating should contain three ounces of silver chloride and nine to twelve ounces of 98 per cent potassium cyanide per gallon of water. It is best to make the solution by rubbing the chloride of silver to a thin paste with water; dissolving nine ounces of cyanide in a gallon of water and adding the paste, stirring or shaking until dissolved, and then adding cyanide until the solution works freely.

A cyanide bath may be prepared, and the silver worked into it with a battery, by using a strong current and large anode and small cathode, but it presents no advantages over the one made with chloride, and this mode is used only when the workman is away from ready communication with a dealer in supplies, or his bath has become spoiled by accident and he has not time to make another in the regular way, and must get his work out. In either case the baths should be filtered when made, and from time to time while being used, in

order to keep them clean; and the dirt from the filters should be saved and sent to the refiner, as it contains considerable silver.

The main thing in working a silver bath is to keep the proper proportions between the silver, cyanide and the current. If there is not enough cyanide in the bath, its resistance to the current is greatly increased, and the plating becomes irregular in consequence; if there is too much cyanide the work does not plate readily, has a yellowish or brownish color, and peels in scratch brushing, or if the excess be very great the object will not be plated at all but will give off bubbles of gas. Similarly, a weak current requires more free cyanide than a strong one. With a little experience the operator will soon learn to judge his bath by the appearance of his work, and to add silver or cyanide to the bath, or increase or decrease his current as required.

Quantity and Strength of Current. The most suitable strength of current for the bath given above is one-half volt and the deposition will require one-fourth ampere of current for each fifteen inches of surface coated. As the Smee cell is one-half volt, it is generally used, and the current is closely approximated by making the amount of zinc surface immersed in the

battery equal that of the objects in the bath, which can be done by using two or more cells and coupling as many as desired for quantity (all the zincs together and all the platinums together) for the plating solution, and coupling for intensity (zinc, platinum, zinc, platinum, zinc, platinum) for the striking solution, which requires a stronger current and a solution weaker in silver. Any other battery will do as well, provided the above conditions are observed.

Appearance of the Work and Anodes. The objects being coated should assume a dull white color; if the color is bluish the bath needs cyanide; if the white coating forms quickly and changes to a crystalline structure, turning dark, metal is wanting. If copper and brass articles dipped in the bath are coated with metal without any current, there is too much cyanide. The anodes should be white when no current is on and become gray while plating, changing back to white when the current is off. If they remain white during the plating, there is too much cyanide; if they remain dark when no current is on, the bath needs cyanide. When the bath needs cyanide, it should be dissolved in water and added a little at a time, to avoid getting in too much. When silver is needed, a little chloride should

be rubbed to a thin paste with water and added, or the quantity of anode surface should be increased. Unless correcting the bath, the surface of the silver anode should equal that of the work, as otherwise the solution is constantly being stripped, and chloride must be as constantly added to maintain its proportions, which is more costly than using larger anodes.

Striking Solution. The striking solution is made by taking a quart of the plating solution and adding three quarts of water and three ounces of cyanide. It should be worked with a strong current as above described, and should give a firm, even and very adhesive coating of silver, of a yellowish color, giving off gas freely from the object in the bath. This yellow coating is used merely as a binder between the object and the silver plating, hence the articles are placed in the striking solution after being cleaned, and transferred to the regular bath as soon as they become thinly and thoroughly covered with the striking coat.

Correcting the Bath. After working a silver bath for some time it will gradually thicken and also become dirty, owing to dust from the atmosphere and other impurities which have been carried into the bath

with the work, and also with the cyanide and silver which have been added from time to time in correcting the bath.

When silver chloride is added, it is attacked by the free cyanide and decomposed, forming cyanide of silver and chloride of potassium. The latter is a readily soluble salt and remains in the solution. When the cyanide used contains potash, instead of being chemically pure, the potash remains in the solution and slowly turns into carbonate of potassium by the action of the air. When this takes place to a considerable degree the silver deposited becomes dull, porous and spongy, owing to the interference with the current by the increased resistance of the bath. This is corrected by slowly adding hydrocyanic acid until the precipitate in the solution is nearly all dissolved, and the deposit is once more firm and of the proper color, when the bath should be filtered to remove the dirt and other impurities. Always save the residue from filtering and send to the refiner.

Great care must be exercised in handling any bath containing cyanide, as it is a deadly poison. Be very careful never to drink from any vessel that has been used in handling cyanides (or prussiates) in any way, or to handle them with cut or scratched fingers. Never fill a syphon by sucking, for the same reason; it has

killed many a man who was too careless to do his work properly. The way to fill a syphon is to plunge it in a pail of water, or fill it from a hydrant or wash bottle, and then when the tube is full of water, close the two ends firmly with the fingers and place one in the solution to be syphoned, and the other in the vessel to which it is to be transferred; then open the upper end of the tube and finally the lower one. If handled in this way large tubes may be used and syphoning rapidly done.

If the bath becomes too foul to be corrected in this manner, take it into the open air where the gas can escape freely, and add hydrochloric acid until the silver has all been precipitated as chloride. Draw off the solution from the precipitate with a syphon, as described in making chloride of silver; wash it thoroughly, dry it and mix with twice its weight of carbonate of soda, and half its weight of pulverized charcoal. This mixture is then fused in a crucible and allowed to cool, when on breaking the crucible a button of silver will be found in the bottom. This may then be redissolved in nitric acid and turned into chloride as previously described, or used as metal anodes in forming a new bath.

Amount of Silver Deposited. The following table shows the amount of silver generally deposited upon

plated ware, and may be regarded as sufficiently close to serve as a general standard:

AMOUNT OF SILVER DEPOSITED ON PLATED-WARE.

ARTICLES.		PWT. SILVER.	GRS.
Table Knives	per doz.	10	
Desert and Tea Knives	"	8	
Butter Knives	"	10	
Spoons, Table	"	10	
" Dessert	"	8	
" Tea	"	5	
" Mustard	"	4	
" Salt	"	4	
" Egg	"	4	
Ladles, Soup	"	36	
Forks, Dinner	"	10	
" Dessert	"	8	
Nut Picks	"		16
Napkin Rings	"	6	
Tea Sets	per piece,	20	
Pots or Urns, Tea	"	20	
" " Coffee	"	22	
" " Small	"	18	
Pitchers, Ice	"	30	
" Wine	"	20	
" Milk	"	20	

ARTICLES.		PWT. SILVER.	GRS.
Cups, Cream	per piece,	15	
" Childs	"	5	
Cups, Childs, gold-lined	"	5	
gold			16
Stands, Fruit	"	30	
" Celery	"	15	
" Wine	"	20	
Baskets, Cake	"	20	
" Card	"	15	
Tureens, small	"	20	
" large	"	30	
" extra large	"	35	
Castors, small	"	15	
" large	"	20	
Butter Dishes	"	20	
Syrup Jugs	"	10	
" " with stand	"	13	
Call Bells	"	1	
Watch Cases, 10-18 Size	"	20	
" " Open Face	"	15	
" Dials	"		15

The cost of depositing silver with a battery is from $1.00 to $1.25 per ounce of silver deposited; of this 25 cents will be for battery, and the balance for metal and maintenance of solution, etc. This does not include the cost of preparation of the work or its subsequent burnishing, lacquering, etc.

Sectional Plating is done by placing an article in the bath in such a manner that only the portions subject to the greatest wear touch the solution. After the desired extra thickness has been deposited, the whole article is then immersed and plated as usual, and the margins of the extra coating, which are plainly apparent when the article comes from the bath, disappear in the burnishing.

Turning Yellow. If the objects come from the bath a pure white color, and afterwards turn yellow in the air, this is due to the formation of basic silver salts in the deposit. In such a case dip the articles for a few minutes into a hot solution of cyanide, which dissolves the salts, and then into hot water, after which they may be burnished.

The Double Cyanide Bath. Partly because it is more convenient, and partly because it is erroneously supposed that it requires less cyanide of potassium, a great many amateurs and professional operators in plating establishments make use of the chloride of silver in making the silver solution. Those who have once used the double cyanide solution for electric deposition of silver, will never use any other for large baths. We shall, therefore, give a few hints pertaining to the mak-

ing and the use of a double cyanide of silver solution. To begin, take the prepared nitrate of silver, and do not attempt to make it from the grain or metallic silver, as you can buy it cheaper from the manufacturers of chemicals than you can possibly make it yourself.

In making, say, one gallon of solution, dissolve 2 ounces of nitrate of silver in plenty of water, say, two gallons; then dissolve in a separate vessel, having a spout, about 4 ounces of cyanide of potash, in about one-half gallon of water. From this cyanide solution, pour a little at a time, while stirring, into the nitrate of silver solution. Continue this as long as a precipitate is formed. Pour the cyanide in more cautiously, and in smaller quantities, as you proceed, to prevent getting in an excess of cyanide, which would dissolve the precipitated silver. When the precipitate is no longer produced readily, give the solution a thorough stirring and let it settle for about five minutes; then pour a few drops of the cyanide solution into the nitrate solution, and if no white precipitate is formed, stop; any further addition of the cyanide will cause a loss of silver. Now, if the vessel is large enough to permit it, add more water so as to render the solution less dense, and thereby facilitate the settling of the precipitate. Let it stand until thoroughly settled, so that the liquid above is clear,

and then pour off the clear liquid and add a new lot of fresh water; let it settle again, and pour the liquid off the precipitate. Repeat this washing two or three times, and throw the moist precipitate upon a filter, and once more throw fresh water upon the same, so as to render it perfectly pure. Then, place the precipitate into about one-half gallon of "soft" water (if possible, rain, or distilled water), and add cyanide of potash in solution, until all the precipitated silver is dissolved, and making, with the cyanide solution, about one gallon. Add about 1 ounce more of free cyanide to the solution, when it will be ready for use.

In making a small solution I would suggest that the workman buy the cyanide of silver and dissolve the same in water and cyanide of potash; in other words, take 1 gallon of water, 2 ounces of cyanide of silver, 4½ ounces of cyanide of potash; mix and stir them thoroughly, and filter through closely woven muslin.

Strength of the Current. The intensity of current required for the deposition of silver is about one volt. The articles to be plated should never boil, as in copper and brass solutions. Adjust the surfaces of your cathode to that of your silver anodes, and the two to the strength of your current, to prevent a so-called burned deposit.

Use chemically pure cyanide only. For the electro plating of spoons, knives and forks, richer solutions, say, 3 ounces of silver to the gallon, are used. Two ounces of silver to the gallon, make a fairly rich solution. Let your anode surface be nearly that of your cathode surface, so as not to impoverish your solution, and adjust your current so as to prevent boiling at the cathode.

CHAPTER XI.

GOLD AND ITS USE IN PLATING.

Gold is perhaps as little understood by the average plater as any metal with which he has anything to do and its use has apparently drifted nearly altogether into the hands of a few specialists, who guard their secrets with jealous care and easily displace any would-be competitors by their superior knowledge, which enables them to turn out more work of a better appearance with very much less use of the precious metal. And when we consider the great cost of the metal and reflect upon the care that is taken to save and recover it from the wastes by all manufacturers who use it, it will be readily seen that the specialist's position is a very strong one and that a little gold saved is an important item, and when we further reflect that there is no standard of weight of metal deposited on certain articles, as there is in silver, and that, on the contrary the less gold there is to maintain its appearace in most work, the better, it may be

readily concluded that the man who can spread the least gold over the most surface, and make it stick, has an immense advantage over his competitors in nine-tenths of the work done now-a-days.

In addition to this, no other metal gives so great a variety of shades or color, hardness and wearing qualities, as does electro-deposited gold. A bath made up of chemically pure chloride of gold and used with fine gold anodes will give anything from a pale 16 karat color up to 24 karat yellow, or any number of shades of a coppery red, according to the temperature of the bath and the strength of current used. Each of these shades will vary in its hardness, speed of deposition and wearing qualities.

Furthermore, a gold bath differs from all other metals in the important particular that, while in all other solutions care is taken to keep the strength up by using anodes equal in surface to that of the work immersed in them, the opposite is the rule in gold work (on account of the cost), and as the surface of the work put into a gold solution is frequently ten, fifteen or twenty times that of the anode (particularly in gold lined hollow ware) it follows that the solution is being constantly robbed and must be as constantly doctored if in steady use. This matter is further aggravated by the extreme disinclination of gold to form chemical combinations with

other substances, making it correspondingly easy to release the metal from those combinations, and thus causing it to deposit with great speed, with a comparatively weak current.

From these considerations it will be readily seen that there is abundant reason for the existence of the specialists in gold work and hence we have platers who cannot color, colorers who never plate, and finishers who know but little of plating or coloring as practiced by the two first mentioned.

Nature of the Metal. Gold is one of the most malleable and ductile of the metals; when pure it is of yellow color, becoming paler by the addition of silver and redder by the presence of copper. Unless specially refined, it always contains traces of these metals, which is the reason gold baths made by running an anode in a cyanide solution will not give as rich a color as those made with pure chloride of gold. The specific gravity of gold is from 19.35 for cast, to 20.2 for rolled, and 19.2 for precipitated powder. In melting it exhibits a sea green color. It readily alloys with most metals and is seldom free from some of them in nature. The most common of these are mixtures of silver and copper, but tin and lead form alloys very difficult

to separate from gold and render it hard, brittle and unfit for working. This is not apt to trouble the plater unless he attempts to work up old gold, when he is almost certain to get into trouble from the solders, etc., contained in the old metal.

Chloride of Gold. Pure gold preserves its luster in the air and is not acted upon by any of the acids, such as sulphuric, hydrochloric, nitric, etc. It unites readily with chlorine and then, as chloride, with the mixtures which generate the chlorine; therefore if we take hydrochloric acid, mix with it enough nitric acid to slowly destroy it (thus liberating the chlorine, and place in it some gold foil, wire or sheet, the chlorine liberated from the acid will unite with the gold and form chloride of gold, which will remain in the solution. This mixture of acids is known as aqua regia. The formula is:

Nitric acid.....1 part.
Hydrochloric acid.....2 "

In dissolving the gold it is necessary to have

Gold.....10 parts.
Aqua regia.....11 "

The proportions given are the exact quantities needed. In practice, however, a little more aqua regia is taken in order to allow for loss by evaporation. Cut the gold into

thin strips of ribbons and bend or crumple them in such a manner that they will expose as much surface as possible to the action of the acids; place them in a thin Florence flask and pour in the aqua regia; then set the flask away in a warm place (70° F. to 90° F.), to dissolve, and gently shake it occasionally. Do not cork the flask, as the escaping gas is liable to break it. Ventilation should also be provided for, as the chlorine will tarnish everything it comes in contact with. Or, if necessary, to hasten the operation, the flask may be placed on a sand bath and gentle heat applied, taking care that the mixture does not boil. When all is dissolved the liquid will be of a reddish brown color, getting darker as the surface acid and water are driven off by the heat, when the heat should be lessened to avoid danger of "burning" (precipitating the gold in the form of a brown metallic powder and thus spoiling the operation), making it necessary to add more aqua regia and start over again. Having continued the heat gently until the liquid commences to thicken, withdraw the flame and allow the heat contained in the sand bath to continue the operation. If snfficiently evaporated it will crystallize on the sides and bottom of the vessel, leaving a little thick, syrupy liquid in the center. The liquid is poured off into another flask and evaporated a little further, when it, too, crystallizes

and the chloride is ready for weighing into the solution. If extreme purity is desired it is dissolved in water and again evaporated before using.

From the above description it will readily be seen that taking into account the necessity of starting with pure acids and pure gold, it will not pay a plater to attempt to make his chloride, as unless in some emergency, it will be cheaper to buy it. The operation is given, however, in order that the plater may have a clear idea of the process if it should become necessary to use it.

Percentage of Gold in Chloride. Pure chloride of gold contains 65 per cent of gold and 35 per cent chlorine; therefore, there are 312 grains of gold in an ounce of chloride of gold. It is well to remember this fact, as it affords a ready means of determining the proper amount of chloride to add in making up baths from formulæ which give gold only in the formulæ, and vice versa.

Varieties of Gold Solutions. We now come to the formulae for the baths, and here we will note a wide divergence in practice, as to the amount of metal they contain; they vary from 15 grains of gold per quart up to 320 grains per quart, according as they are to be used

hot or cold and with a battery or dynamo current and also according to the color required.

Proportions of Cyanide. They also vary in the proportions of cyanide used, the lighter baths requiring more free cyanide and the heavier ones less. This cyanide question is largely settled by the current used; a current of 3 volts requiring about ten per cent of free cyanide and a stronger current less until we reach about 8 volts, when the excess of cyanide should be very slight. The reason is that the cyanide reduces the resistance of the bath, allowing the current to pass more readily, and as the metal also performs the same office, we shall interfere with the color and texture of our deposit if the due proportions are not observed. Too large an excess of cyanide yields deposits of an ugly, pale color, as if there were silver in the bath, while too great a quantity of metal has a tendency to cause a red brown deposit if the current is not kept of suitable strength.

Hot baths, for hot gilding, work with from 11 grains to 20 grains of gold to the quart and a considerable excess of cyanide, while those for cold gilding and plating should contain not less than 60 grains per quart and may have 320 grains. The latter high content of gold is used with a dynamo current where great speed is

required and the work is simply dipped in and taken out again, the deposit taking place almost instantly.

Color of the Deposit. There are two ways of varying the color of the deposit. One is by varying the temperature and is generally practiced with hot baths, in which a solution of 90° F. gives a pale color; 120° F. to 130°F. gives a fine yellow, while increasing the temperature to 140° F. gives a reddish color. The second method is that practiced in cold baths and it is accomplished by varying the current. A small current gives a pale color; a medium current a fine yellow and a large current redder tones. A little experience will enable the operator to match colors readily either way, but he must be cautious about getting too much gold on, as the increase of temperature or current strength will hasten the deposit of the metal in a marked degree, making it necessary to correspondingly shorten the time the work is in the bath. Lastly, the operator must determine whether the work is to come out of the bath bright or to come out dull and be brightened under the brush (or left dull), and choose his bath accordingly.

Hot Baths are generally supposed to give a closer texture and finer grained deposit than cold baths, owing

to the superior conductivity of the bath and its greater speed of operation with a weak current. For this reason they are generally preferred for "finishing" large quantities of cheap work, where the thinnest possible layer of gold of the exact color of the metal beneath it is desired, as in the sliding tubes of French opera glasses, brass rims on opticians' trial lenses, brass uniform buttons and other articles which rely about equally on a thin coating of gold and a subsequent coat of lacquer to protect them, and which must be handled in bulk with great speed, being seldom in the bath longer than five to ten seconds. Another important advantage on such work is that hot solutions readily dissolve any greasy matter or film of oxide left on the work through careless treatment, and thus secure a more nearly uniform coating on work which would otherwise have to be handled with much greater care and consequent expense in the preliminary buffing and cleaning.

Stock Solutions. Hot solutions, however, have the drawback of requiring constant doctoring, where large quantities of work are being handled, on account of the surface of the work being greatly in excess of that of the anode and also owing to the fact that hot cyanide has very little effect on metals, while cold

cyanide will dissolve them readily. The usual practice in such places, therefore, is to keep a strong stock solution of gold ready to add to the bath. This is made by dissolving one part of chloride of gold and one (or one and one-half) parts of cyanide of potassium separately, in distilled water, and then mixing the two solutions, the resulting cyanide of gold being all ready for work as soon as put in the bath. Of course it will be readily understood that, as the object is to have a strong stock solution of gold cyanide, it is advisable to use as little water in dissolving the gold and cyanide as will suffice to keep the gold cyanide in solution in the stock bottle. A little reflection will also show that the gold disappears from the bath much more rapidly than the cyanide, so that it will be prudent to use as little cyanide in the stock bottle as will dissolve the gold, or we shall presently have too much cyanide in the bath.

In working hot baths hot water must be added from time to time to make up for that lost by evaporation.

Hot baths are also employed by many on the score of cheapness, as they work with so much less gold in the solution, as previously stated, and also because they may be advantageously used with batteries. When using gold solutions of many different colors for fancy gilding the saving is considerable.

Cold Baths are, however, preferred in manufacturing establishments, where power is readily accessible and dynamos can be used to supply a steady current of uniform strength and any desired quantity. In such cases uniformity of color and thickness of the deposit are the chief objects desired and these are best secured by having large baths made up to special colors and maintained by anodes of the same quality of metal as is contained in the bath, it being better to put the money into large solutions, rather than run any risks of lack of uniformity in thickness and color of deposit on articles which are turned out by the hundred or thousand and afterward carded or boxed in dozens from an indiscriminate heap, as in such cases and difference in the deposit would be sure to show when the goods were carded or boxed. Hollow ware too, is gold lined with cold solutions on account of the greater convenience in handling and the fact that it is sometimes undesirable to heat them after they have reached a finished stage of manufacture. Heavy plating of watch cases, chains, etc., is generally conducted in cold baths, using plenty of current of low voltage and conducting the work slowly, in order to secure a uniform and hard deposit. This, however, should not be confounded with coloring or finishing cases, where the very opposite is the rule.

Strength of the Current. In cold gilding, as in other plating, the operator must always remember that a weak current of suitable quantity to deposit uniformly will give a close-grained, hard deposit, while a strong current, even of less quantity, will give a coarser, more open texture, which increases in the size of the grain with the strength of the current until it becomes crystalline and finally becomes a powdery deposit, which refuses to adhere. This applies to the *strength* of the current, independently of its *quantity*, and should be distinguished from the action of too great a quantity of low voltage, as the latter simply darkens the work until it "burns" it, by causing a powdery deposit as before, without causing anywhere near as great an increase in the size of grain of the deposited gold.

Larger and cold baths also require a greater current strength than smaller and hot baths, as the quantity of surface of work exposed is usually greater and the distance between anodes and work is also greater, thus causing more resistance in the bath which it takes more current to overcome.

Regulation of the Current. When the operator is using current from a dynamo the supply is always ample and regulation becomes merely a question of

shutting off more or less current according to circumstances; this is done as follows: A wire that is just large enough to carry the most current that will be required is run from the dynamo to the bars on top of the vat containing the gold solution. If a resistance switch can be afforded it should be placed near the vat, on the positive wire from the dynamo, so that the operator may reach the switch to adjust the current without leaving the bath. The current should not be over 6 volts and 3 to 4 volts is better. If the current is too strong, it may be run through a spool of double covered office wire to cut down the strength. Then the anodes should be attached to the bar of the vat by a much smaller copper wire, leaving it long enough so that the anode may be plunged partially or entirely into the solution, at will. Now, the greater the anode surface immersed, the less the resistance will be and the more current will pass, therefore the amount of anode surface immersed will govern the current.

When handling large surfaces, especially in cold solutions, it is desirable that the gold shall immediately cover the work in order to protect it from the free cyanide of the bath and save fouling the solution; therefore the workman first connects his wire from the bar to his work, then immerses it in the solution and immediately

takes the anode, plunges it far enough into the bath to get sufficient current and moves it about near the parts of the work that do not become coated immediately. thus favoring those parts. When the work has become evenly coated all over with gold, the anode is withdrawn until the current is right to produce the desired color and the deposition then proceeds more slowly. This method of current regulation by the anode is the same for both cold and hot solutions and for dynamo and battery currents; but in working with a battery (lining hollow ware for instance) the workman should always make sure that his solution is rich in gold and that he has current enough to coat evenly at the start, otherwise the coating will be uneven and may not stick at all; so most workmen prefer to be on the safe side and couple up cells enough to give plenty of current of the proper strength. Sometimes in lining water pitchers or other deep vessels, in which the solution is poured into the vessel instead of putting the vessel into the bath, it will be found that the anode is too small to move about as described; in such cases the wire from the work is unfastened and moved about on the outside of the pitcher in close contact with it so as to control the deposit by favoring those portions that are slow. This method, while not equal to the other, will aid matters.

Color of the Deposit. In working cold baths, if the color is too pale, while the deposit is good, there is either not enough current or too much free cyanide for the amount of gold in the bath. Put on more current in such a case and if that does not remedy the color add more gold cautiously until the due proportions of gold and cyanide are restored. If the color is too red, reduce the current and if that does not fix the color there is too much gold and not enough cyanide in the solution, so, of course, we add cyanide and water slowly.

In working hot baths we have another factor (the temperature) to consider. Below 120° F. the color should be pale; 120° to 130° F. should give a fine yellow; 140° to 170° F. gives red shades. Warm up a thermometer, so as not to break it, and put in the bath. If the temperature is right, then change the current and finally the solution.

By always examining the current first and then the bath (in cold baths) and temperature, current and bath in the order named in hot baths, the workman will run no risk of getting a good bath out of order.

Any work should be immediately coated with gold on being placed in the solution. If the deposit takes place only on the parts nearest to the anode, or if the work is coated and the gold is afterwards dissolved off again, the

current is too weak or there is too much free cyanide. Change the current first; then look after the bath. If the deposit takes place too rapidly it will be irregular, patchy or spotted; then the work should be well scratch brushed and the current changed and finally the bath as before.

Formulae for Gilding and Plating. Platers who have thoroughly understood our remarks on the management of gold baths, will have no need of any formulæ for gold baths, as they will be able to make or fix up any required baths from their knowledge of the metal, cyanide and current, without any special formula. Still, we will give here a few of those in most common use, with observations on their nature and use, for the benefit of those who may desire to experiment a little with them, to learn the capabilities of each.

Baths for Steel and Iron. In gilding direct on steel and iron (without a previous coating of copper) the baths should contain less gold than for other metals, it being generally sufficient to take a portion of the regular bath and add water and a little more cyanide of potassium, until the desired color is obtained. Too much gold gives a dark deposit, which does not adhere

as well to the steel. If the workman happens to be using a bath that is low in gold, he can usually obtain the desired color in his regular bath without trouble, by using a weak current. The deposit should start slowly on steel, or it will not adhere well:

Bath for Bright Gilding. A formulæ for depositing a coating of gold that will be bright after rinsing and brushing, is as follows:

Potassium Ferrocyanide	2 ozs.
Carbonate of soda	2 ozs.
Fine gold (as chloride)	5 pwts.
Water	1 gal.

Dissolve the ingredients separately in portions of the water; add the soda solution to the potassium solution, and heat to the boiling point; then add the gold solution and boil for about fifteen minutes. After cooling add sufficient water to make up for that lost by boiling, and filter. This gives a fine bright color on all metals, even iron and steel, if used with a current of about three to four volts.

Carat Solutions. Dissolve 14 ounces of cyanide of potassium to each gallon of water; heat to 120°-140° F., and suspend two anodes of the desired quality of

gold in the solution, and run them until the solution contains sufficient metal to deposit well. In making solutions by the battery process, the operator should change the depth of his anodes from time to time, as they are liable to be cut through at the water line unless this is done, the action being greatest there. The anode to be stripped should also be much larger than the other.

Red Gold Solutions. If the operator happens to have a cyanide of copper solution, he can make up various shades of red gold solutions by mixing various quantities of the two solutions. The color depends on the relative quantities of metallic gold and copper in the solutions. Ten per cent of copper gives a pale red; 20 per cent of copper a fiery red, and 30 per cent gives a deposit of a copper color, but which will not tarnish; or the solutions may be made by dissolving cyanide of copper in water and adding it to the gold solution. If the cyanide is not at hand, dissolve carbonate of copper in cyanide of potassium, with a little water, and the same end is obtained. They should be worked with anodes of the same composition as the solution, or a fine gold and a copper anode of proper proportions may be hung side by side in the solution.

Green Gold. Increasing the quantity of silver in a carat gold solution will give greenish shades, if the current is properly regulated. It is not easy to do such work uniformly, however, as the current has to be nicely regulated according to the surface of the work. Too weak a current will deposit more silver than gold, and too strong a current will deposit more gold than silver, making a yellowish instead of a green color. With a resistance box and a constant source of current a very pleasing green-gold may be obtained, which will do a great deal to brighten up medal work especially if used in connection with red shades.

Pale Straw Colored Gold. This is obtained by adding to the ordinary gold solution a small quantity of cyanide of silver, previously dissolved in water, and working the solution cold with a weak current and small anode, keeping the work constantly in motion, to brighten the color and secure a uniform deposit.

Rose Colored Gold. This is obtained by adding suitable quantities of copper and silver cyanides to the gold solution; but it also requires close attention to the proportions of current and work. Hot baths are the best for this solution.

Nickel and Gold Solutions. Probably one of the most useful alloys of gold for platers is that with nickel; besides being cheaper it has a much richer color than a solution containing gold and silver and gives a correspondingly better appearance to the finished work, or, which is the same thing, permits a much larger proportion of the cheaper metal to be used for a carat color. In addition to this it is much harder and wears better in consequence on large flat surfaces, or edges exposed to wear, such as watch cases, chains, harness trimmings, etc. It is in use in many of the case factories and a number of the large finishing shops of the East. Like the solutions given above, it is made by adding cyanide of nickel to the ordinary gold cyanide bath and working with anodes of the same composition. The solution may be made by dissolving from anodes, as given above for gold, or it may be made by dissolving double sulphate of nickel and ammonia in water to which cyanide of potassium has been added, boiling to expel the ammonia, and then adding the solution to the ordinary gold solution. Carbonate or chloride of nickel may also be used, dissolved in cyanide as above. We have not given proportions, as very few use any exact formula; in a general way it may be stated that the usual practice is to use 30 parts of nickel to each 100

parts of gold. It requires a nice balancing of current and solution to get a bright color, the nickel working best with a strong current and the gold with a weak one.

Proportions of Metal in Various Salts. In making solutions from anodes the proportions take care of themselves; but in making them from salts it will be necessary to ascertain the amount of metal in each salt and proceed accordingly. If the workman is not able to do this for himself, he should get a chemist to calculate for him the various quantities of metals in the chemicals he is using and make a list of them for reference; then if, for instance, he desires to make up a gold solution containing 1 penny-weight of gold to the gallon he would know exactly how much chloride of gold he needed for that solution. By proceeding in this way he will avoid guess work and save much valuable time and expensive materials. This is extremely important when it comes to handling large solutions or a great number of small ones, each of different composition.

Effects of Varying Strength of Current in Depositing Alloys. In working any solution containing more than one metal, it must be borne in mind that each metal

has a certain current strength at which it will deposit most freely, and that if the work be done with this strength of current, that metal will be deposited in excess of the others, and in aggravated cases to the exclusion of the others. Thus it is possible to deposit either zinc alone or copper alone from a brass solution, or gold alone from a nickel and gold solution. A certain plater in New York City has recently published a book in which he states that no mixed solutions are capable of doing good, practical work for any length of time, a statement which has caused much amusement to the platers who are doing architectural work in brass and bronze in Chicago and other large cities, plating columns 15 feet long and 18 inches in diameter, panels 36x72 inches, elevator work, etc., in bronze, composed of copper, zinc and tin, brass plating on stove castings, etc. The whole secret is in the proper regulation of the current, both as to quantity and strength. Once the proper current is found, the difficulty ceases as long as that current is maintained. Hence, in working with mixed solutions the workman should have a means of varying the voltage and quantity of his current, and of reading the voltage and amperes of the current, so that he may compare them with his work. Volt meters and ampere meters are expensive, but they will teach a

workman more about his work on mixed solutions in one month than he can learn otherwise in ten years.

Necessity of Skill. In no other branch of electro-plating is skill more necessary than in gilding or gold plating. While it is comparatively easy to obtain some kind of a gold covering on an article, it is often an altogether different matter to match a color or to obtain a thin, hard and brilliant coating that shall be durable without being costly.

The Durability of gold plating does not depend altogether on the time it is in the solution. If the current is about two or three volts (about equal to a Bunsen cell, or two Smee cells connected for intensity) and the quantity is proportioned to the work in the bath, then if the solution be worked at 120° to 130°, which also deepens the color of the deposit, it is possible to get a coat inside of five minutes that will last for several years.

It is always best, when other conditions are all right, to keep the work moving and immerse the gold anode sufficiently to suit the surface of the work that is being plated; care should be taken not to allow the work and anode to touch each other, as a black or burned spot

will be left on the work wherever the anode touches it. After getting the first slight coat of gold, the work should be scratch brushed with a fine brass scratch brush (wire about .003 inch), letting a little soap suds drip on the brush. This lays down the first coat of gold, which should be sufficient to cover the article entirely. The scratch brush acts as a burnisher. After this it is thoroughly cleaned of the soap suds in hot water, and again placed in the solution. The time it remains will have to be governed by experience, but generally five minutes will give a sufficient coat to stand burnishing.

Coloring is always done with pure gold, and the best workmen take especial pains to see that no silver is allowed in the solution. They do this by using only the best chemicals, and frequently evaporating their baths and parting out the silver with nitric acid. By this means they obtain an immense advantage over others in the brightness and thinness of the coating of gold deposited, and an advantage which shows chiefly on the ledger of the establishment, and in the reputation of the house for quick and skilful work.

A cold solution will give a pale color; increasing the temperature to 140° gives a reddish color; 120° to 130° gives a fine yellow. The reason of this is that heat

hastens the chemical reactions in the bath, and the gold deposits much more rapidly, so the operator should look out not to deposit more gold than he wants, and thus strip his solution. The anode surface should also be less with the hot solution.

Finishing may be done with steel and agate burnishers, the same as with silver, or the articles may be polished with a soft cotton flannel buff, run at 2,500 revolutions per minute, and bearing a very little of the finest rouge, mixed with alcohol. If you run your wheel too slow the layers of cotton will not stand up, and you will not get a polish; 2,500 to 3,000 revolutions is about right, and the pressure should be light and even.

CHAPTER XII.

ORMOLU FINISHES AND DIPS.

The return of ormolu into favor and its consequent extended use in finishing clocks, statuettes, furniture trimmings, desk ornaments, paper weights, etc., is sure to bring with it demands upon the younger platers for a knowledge of this finish that they may find it extremely difficult to attain; consequently a short historical sketch may be of considerable use and interest to all who have spent less than twenty-five years in the business.

Ormolu as originally produced, was a golden yellow alloy composed of copper, 583 parts; tin, 167 parts; zinc, 253 parts. The large proportion of tin gave it easy flowing qualities, so that very sharp castings were obtained. Sometimes the proportions were a little altered so that an excess of copper gave it a reddish color nearly resembling that of the then popular Roman gold. The idea was in all cases to produce an alloy that exactly

matched the color of the gold that was afterwards placed upon it, so that very little gold should be necessary to produce a durable smooth and elegant finish. In all cases the object was buffed bright and perfectly smooth, then dipped in potash, pickled and washed in hot water to remove all grease, and finally, fire gilt. Sometimes portions of the object were burnished, leaving the rest a matt surface, giving strong contrasts of great beauty; sometimes it was left entirely matt, giving a sort of half luster surface, exceedingly soft and yet brilliant; and sometimes it was left a dead surface similar to the satin finish of to-day. The second of these (the dull luster) was regarded with the greatest favor and required the most judgment to produce, as a little too much gold was certain to make a dead surface, while too little rendered the work uneven. After finishing, the work was lacquered, and as the fire gilding without burnishing gave an exceedingly open deposit, the lacquer penetrated deeply into it and lasted a very long time.

The above was the original ormolu, and many specimens are still to be seen with their original lustrous softness unimpaired by twenty-five or fifty years' use under glass shades or other covering. Others, originally as good, have had the gold rubbed off them by continuous dusting, or perhaps the energetic use of soap and water,

so that there is a dark brown stain on all the high light and large surfaces, while the less exposed parts show traces of their original beauty. Much of this old bric-a-brac will be gathered up from the garrets and brought to the plater, now that it is once more in fashion.

There was also another finish called ormolu, which contained no gold and was inferior to it in durability, but had almost as much luster when new. This was much used in furniture, grates, andirons, and fenders, etc., of the cheaper class, and is now coming back with a rush. It is produced entirely by various dips and then lacquered to preserve the color thus obtained.

In repairing or refinishing the genuine ormolu, all previous coatings of lacquer should be taken off, the object buffed bright, then dipped successively in caustic potash, hot water, a bright acid dip, again in hot water and then into the gold bath, where a very thin deposit of gold of just the color of the bronze used in the object should be laid upon it. The current should be regulated to give a very fine and smooth deposit, and one that is as bright as possible. When the coating has reached the color desired, it is at once removed, washed thoroughly in hot water and lacquered. The great object to be obtained is to use so little gold and have it so evenly distributed that the metal shall be effectually

protected from tarnish without losing all of its polished appearance. Too much gold will give a dead or satin finish; too little will affect its durability.

Ormolu Finish on brass work is usually confined to producing the light, bright yellow, which nearly approaches the color of fine gold, and we give below two formulae, which vary but a trifle in their composition. Either will do the work, but both require a little judgment to obtain the proper effects, and this can only be obtained by practice, as the principal knowledge required relates to the length of time to immerse the work to obtain the desired effect in the various baths.

The work is first cleaned in the ordinary way with hot caustic potash; then in an ordinary cyanide dip to remove any stain caused by the potash; wash in hot water; then dip for several seconds in nitric acid, to which has been added ten or fifteen drops of muriatic acid per gallon of the nitric acid. When this acid bath is first made up, it is sometimes an advantage to place a piece of brass in it for a few minutes, to deprive it of some of its strength. After dipping in this, wash in clean water, and remove to dip No. 2, which is composed as follows:

Nitric acid..... 1 pint.
Sulphuric acid..... 1 pint.
Sulphate of zinc (crystals)..... 10 ounces

This should be well stirred before using, part of the zinc sulphate remaining undissolved. The work is left in this for three or four seconds, and washed in running cold water, then dipped in hot water, and dried in sawdust, when it is ready for lacquering. If the color is not "satined" enough, repeating the dips and washings as above will deaden the surface still more.

The lacquer used is generally a celluloid or other colorless lacquer, with a little gold lacquer added to it to get the proper shade.

The second method consists of cleaning and buffing as usual, then dipping in a bright dip, consisting of

Sulphuric acid	1 gallon.
Nitric acid	3 pints.
Water	1 pint.
Common table salt, a handful.	

The object is then washed, and dipped into the ormolu dip which consists of

Zinc carbonate	5 lbs.
Sulphuric acid	15 lbs.
Nitric acid	15 lbs.
Pulverized saltpeter	1¼ lb.
Muriatic acid, one cup, little at a time.	

Care should be taken in mixing the above, as unless it is done slowly and carefully, there is likely to be trouble from the ebullition of the acids. When the dips are

properly constructed for the metal used, an instantaneous immersion in the bright dip, followed by hot water, then the ormolu dip, and again by hot water, and drying in sawdust, will give the lustrous surface spoken of; repeating the operation will give a satin finish.

This formula is in daily use in one of the large establishments of this city, and gives the result with a speed and certainty that leaves nothing to be desired, with the additional advantage that almost any shade of gold may be given by varying the tint of the lacquer.

CHAPTER XIII.

BURNISHERS AND BURNISHING.

Burnishing, while once regarded as indispensable to the production of a smooth, hard and durable surface, after plating, is gradually being given up, as the operations of polishing and plating are better understood, and it is now generally acknowledged that if the work has been properly smoothed in the polishing room, properly cleaned and plated with a current that will give a hard and tough (but not brittle) deposit, there will be no need of burnishing; simply buffing bright with soft rouge and very light pressure, will make a fine looking job in such a case. If the deposit is soft and spongy, from too strong a current in plating, or if the polishing or preliminary cleansing be imperfectly done, so that the job will not look well or wear well, matters can be considerably improved by burnishing, as it will press down and harden a soft deposit and smooth over rough and spongy places caused by imperfect cleansing or faulty

polishing. Many things which require a bright finish only on certain portions while the rest of the surface is left matt, such as scrolls, shields and borders on hollow ware, or centers and margins of trays, can be more quickly done by burnishing than with small and thin buffs, particularly if the margins of the bright surface be formed of curves and angles, as is often the case.

Burnishers are of two kinds, hardened steel and agate or bloodstone. It is usual to go over the work first with steel and then with stone burnishers in order to get a very smooth and hard surface, if the workman be only moderately skillful. Skilled workmen, however, will obtain a presentable job with one operation and such men generally confine themselves almost exclusively to the use of steel burnishers, as they cost much less, are stronger and not so easily broken as the stone, and while in every day use are easily kept in order.

Stone Burnishers. One point which it may be well to remember is that when you buy burnishers of agate or bloodstone you purchase them absolutely, not with a privilege of trial; they will not be taken back or exchanged for others by the dealer nor can they be

returned if, as often happens, flaws develop during the first day or two of their use. The burnishers selected by the plater will have to be kept by him if he purchases them. The reasons for this are that the tools are carefully made, are subject to inspection before purchase, and are so hard that they are easily broken by a fall or an accidental blow while in use. Such a blow may start a crack in the stone, which may develop into a chip a week afterwards, and then the workman is ready to swear that it "came out of itself" under proper usage. These are a few of the reasons that discourage the use of stone burnishers among workmen, although they admit the advantages of such tools over steel. These are superior smoothness and consequent ease in working, greater durability of the burnishing surface and less tendency to fill up with metal, and less loss of time spent in polishing up the tool.

Steel Burnishers. In many respects, too, the steel burnishers are subject to the same tendencies as the stone, although they vary more in texture. The closer grained and harder the steel becomes, the smoother it can be made, and the longer it will wear, and also the greater will be its tendency to chip or crack, for steel that is "glass hard" is easily broken.

Although but little inferior to stone in the hands of a skilled workman, the novice is very apt to cut his work with steel burnishers, by failing to keep the surface of the tool polished and free from metal, or by filling the tool with too hard pressure, or by holding it at such an angle that it will drag the surface of the work instead of gliding over it and pressing it down evenly and firmly.

Differences in Metal. Like most other simple operations, burnishing is almost entirely a matter of personal skill and proficiency, and can only be acquired by practice. The objects to be attained are smoothness and uniformity of surface and speed in producing them. The plating in small shops using batteries, or those using dynamos, in which the plater is careless or unskillful, will vary greatly in its texture. Sometimes it comes out soft, thick and spongy, and at others thin, close and so hard as to be rather brittle, varying according to the strength and quantity of the current and the proportions of cyanide and metal in the bath: The burnisher, therefore, works upon varying textures of metal, and he is expected to largely correct the faults by burnishing all to a hard, durable coating, if he is doing "bright" work. Of course if the work is to be left matt, and only rims.

borders and escutcheons are burnished, he will be unable to do anything to correct the matt portions, but the difference will be felt on those portions which he does burnish.

Method of Using. The tool is grasped firmly in the right hand, with the burnishing end close to the little finger and the forearm resting on the edge of the bench. Then with a firm, steady pressure, the tool is moved backward and forward, without taking it from the work. The tool is kept constantly moist by dipping it frequently in a bowl of soapsuds standing on the bench, and it is kept polished by rubbing the burnishing surface on a piece of leather nailed on the bench and having a little tin putty or Vienna lime and oil on it. A piece of thick walrus or sea-horse, nailed flat, is generally used and by passing the burnishers over it the narrow way (as if you were cutting it with a knife), the tool soon makes itself a track that fits perfectly and thus polishes the whole surface at once, saving time, as a stroke or two on the leather covers the entire surface. Different widths of tools will of course have separate tracks on the leather.

The tools are of different shapes to suit various requirements of the work, Fig. 27, and the first burnish-

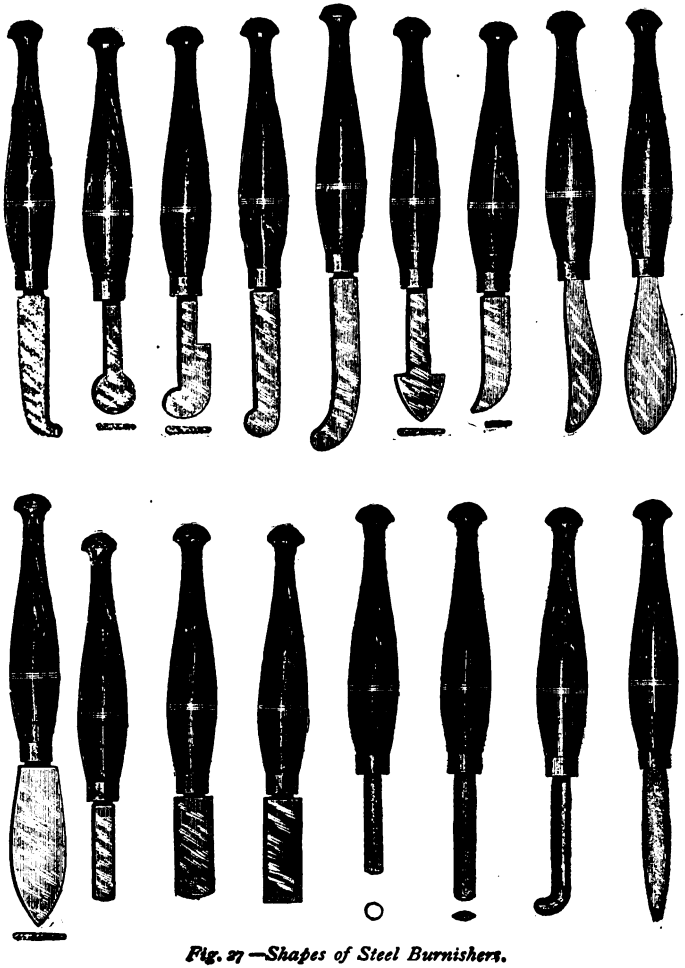

Fig. 27.—Shapes of Steel Burnishers.

ing is done with tools of comparatively sharp edges, while the finishing is done with much rounder ones, although, as the workman acquires skill, he will go over his work less and use fewer tools, gradually settling down to a few forms which he finds best suited to his run of work.

Brittle deposits must have just sufficient pressure to smooth the work; coarse and spongy metal needs harder pressure. Caution must be exercised in inspecting the work before beginning to burnish, as unless it is known to be all right, the metal may be stripped off from faulty places in the work by too much pressure, and this is pretty sure to be followed by a quarrel between the burnisher and plater. The former maintains that the work was not properly plated, and the plater alleges that it would have stood all right if the burnisher had not stripped it through carelessness. In any case the work has to be done over.

CHAPTER XIV.

SOME FINISHES FOR PLATERS.

One of the most vexatious questions that annoy the average plater is that of finishing or "coloring" his work. I was in a supply store recently and overheard a customer say to the salesman, "That silver solution you sent me isn't right at all. I want black silver. This plates all right, but is as white as the pure metal, and I want that black silver that is seen everywhere now-a-days." The salesman seemed to regard the protest as an everyday affair, and calmly explained that the black color was produced afterward, giving some simple directions, and he departed apparently satisfied and certainly wiser.

This set me to thinking, and after overhauling a lot of old formulas, containing almost everything, from bills and livers of ducks to chloride of gold and platinum, I began to wonder how many of those who used those recipes realized what they were doing, and it occurred

tc me that perhaps a few plain words on the chemistry of these finishes might be of service to the younger generation of platers. In the first place it will be evident that all these mysteriously compounded recipes are simply intended to tarnish the bright metal. Now, most of the colored compounds on silver, copper and brass consist either of sulphides, chlorides or carbides; that is, of a union of sulphur, chlorine or carbon with the metal upon which the discoloration is to be produced. This being clear, it follows that we must use those compounds in our dips which have the sulphur or chlorine held in very feeble union with the base, so that it will readily part from that base and unite with the bright metal when it is dipped in the solution. This is practically all that there is to the dip, and it will be readily seen that the vast quantity of stuff put into many of the recipes is utterly useless, in fact, worse than useless, most of them being a positive detriment.

One of the compounds most generally used is the pentasulphide of potassium (liver of sulphur). It parts readily with its sulphur, and the potassium being left free in the solution, attracts oxygen first, then carbonic acid from the air, and thus becomes caustic potash, which is too well known as a cleansing agent in the plating room to need further comment.

A solution of one ounce of liver of sulphur to the gallon of water should be made up and allowed to stand over night, when it will be ready for use with either silver, copper, bronze or brass. The next requisite is to obtain a surface on the metal that will take the sulphur evenly. This is done by exercising the utmost care in regard to cleanliness. If the color is uneven, light in some places and dark in others, or filled with dark spots, or light spots, you can decide that the metal is not clean when it is dipped. The work is cleaned as for plating, and then brushed with powdered pumice stone evenly all over, rinsed in hot water, and then dipped in the liver of sulphur and allowed to remain until the right color is reached, when it is removed, dipped in hot water, dried, and lacquered.

This brings us to the question of color, which depends altogether upon the strength of solution and the length of time the work remains in it. An instantaneous dip will result in a gray color on silver, and it gradually deepens as the time is increased, until the metal is entirely hidden. Midway between these are any quantity of semi-transparent shades of great beauty. With copper, tones can be obtained ranging from an ochre color to deep black, according to the depth or transparency of the deposit. Brass can also be similarly shaded. The

strength of the solution given above is suitable for all but the lightest shades; for these it is advisable to add more water. The workman will see that there is a large margin left him for taste and skill in using these dips, as is always the case in simple operations, and if he will patiently learn how to do them, by experimenting with the various metals, he will be well repaid for his time and trouble.

One of the most useful dips for platers, next to the liver of sulphur, mentioned above, is the green. This is generally used on brass, more rarely on copper and silver, and frequently on zinc. The same rules as to cleanliness of the object and the length of immersions, washings, etc., apply to all these dips, and it will be understood without mentioning them in future.

Green, Red or Brown Bronze for Brass is frequently used on statuettes, either of brass or copper, builder's hardware, etc., and is composed of

Hyposulphite of sodium	4 ounces.
Nitrate of iron	4 ounces.
Water	1 quart.

Dissolve the iron and soda in the water, and allow to stand until thoroughly incorporated. Then dip the article as previously described. On being immersed

the article turns brown, then red, and finally green, so that it will readily be perceived that any number of shades can be produced with this dip.

Olive Green on Brass is made by immersing in

Perchoride of iron.....1 part by weight.
Water .....2 parts by weight.

This dip produces green tints ranging from a pale to a dark olive green on brass, according to the time of immersion. The articles, after being buffed, should have all grease removed by being dipped in hot potash, then in hot water, then in a solution of cyanide, made up of one-half pound of cyanide of potassium to each gallon of water, and finally immersed in the green dip. If the color is uneven, the treatment with pumice stone previously described must be applied.

Frequently articles brought in to be repaired or cleaned up are from some cause, such as worn plating, etc., unsuitable for dipping, as the color would be very uneven, while it would not pay to strip and replate. In such cases the color is applied in the finishing lacquer.

Green Patina on any Metal. Carbonate of copper, or verdigris, or any suitable mixture of the two salts, according to the tint desired, is mixed in zapon

lacquer, or any light colored varnish, and applied to the object with a brush, and the high parts immediately wiped off with a rag dipped in the proper solvent for the varnish. If zapon or other celluloid lacquer be employed, the rag should be dipped in "lacquer thinner," (acetate of amyl); if an alcoholic varnish be used, then, of course, alcohol should be used on the wiping rag. It takes a little experience to get the necessary touch to leave a smooth and even coating on the object; when this is once acquired, however, the work is accomplished as quickly as plain lacquering, and can, of course, be used on any metal. A fine coat of clear lacquer should be given after the bronzing coat is dry, to protect the bare parts of the metal from oxidation.

Light Green on Sheet Zinc. A very nice light green may be imparted to sheet zinc by means of the following: Dissolve 10 parts of hyposulphate of sodium in 100 parts of water in a well glazed stone crock or a glass jar and then add to it slowly, with constant stirring, 5 parts of sulphuric acid. The liquid will become hot by the addition of the sulphuric acid, and it should be allowed to cool until the milk of sulphur settles in powder or lumps at the bottom. Decant the liquid containing sulphate of sodium and sulphurous acid and

place the zinc articles into the same, after being heated to at least 150° F. A light green will be produced in a short time. Wash, dry and lacquer. The work must in all cases be clean and free of grease. The better the polish the more brilliant the resulting color.

Mat or Matte Silver Finish on Thermometer Scales, Clock Dials, Etc. Heat the articles, if they have no soft soldered parts about them, in an alcohol flame or Bunsen burner, and plunge them while hot into a cold pickel of 100 parts water and 10 parts sulphuric acid, previously prepared by pouring the sulphuric acid slowly into the water while stirring. Rinse off the articles, dry and lacquer. Never pour water into acid.

Pink on Silver. Pinkish colorations on silver surfaces are produced by immersing the articles for a few seconds in a hot concentrated solution of chloride of copper; wasn well in water, dry and lacquer. Where there are copper plating solutions and electric current at hand (battery or dynamo), a still better result can be obtained by giving the articles just a flash of copper in a sulphate of copper solution, and upon this rose colored deposit a thin coating of silver in a cyanide of silver solution, and thus blend these two deposits.

CHAPTER XV.

THE METHODS OF USING LACQUERS.

With the exception of nickel and gold, all the work turned out by the plater is greatly improved in appearance and the durability of the final polish by having one or more coats of lacquer applied to it before delivery to the customer. In the case of easily tarnished metals, such as brass or copper, and when the final color has been produced by dipping, this is a necessity.

The oldest lacquers were simply transparent varnishes, generally of shellac and alcohol, applied very thin, and repeated two or three times, to get the necessary thickness and perfectly cover the metal. With the invention of celluloid and its application to so many articles of ornament and use, came the death blow to the gum lacquers, as it was speedily found that celluloid could be dissolved in acetate of amyl and acetone and, thus prepared, made a harder, tougher, more transparent, more durable and cheaper lacquer than any of the

combinations of gum and alcohol or other solvents. It is more easily handled, can be colored more readily, and is the only colorless lacquer, and therefore the only one perfectly adapted to silverware.

The celluloid lacquer is sold in the market under various names, but may be classified under two general heads, colorless and colored. They are largely sold in various grades, adapted for special purposes, and if the plater is doing a special line of work he will find it most economical to buy his lacquer as specially prepared for that work. Those doing a large variety of work, or desiring to experiment, will find it of advantage to buy colorless lacquer, colors and "lacquer thinner" and mix colors to suit themselves. Lacquer colors are specially prepared and are sold in a concentrated form, so that the novice must be very careful not to get in too much. They dissolve readily in the lacquer, but do not become evenly distributed throughout the whole of the fluid for some hours, so that care must be taken to mix them the day before they are to be used, if more than a few ounces of a special color are to be made up.

Large establishments have a room (free from dust) heated to 140° F. and provided with a chimney or other means of draught to carry off the fumes of the acetone,

which are disagreeable to many persons. The lacquer is placed in a wooden or enameled iron vat, and the articles, perfectly clean and warmed to 100° or 110° F. are hung on hooks and dipped into the vat, taken out turned about a moment to allow the superfluous liquid to run off, and hung up to dry. The lacquer thickens up in use and must be diluted from time to time with the "thinner." If too thick, the work is uneven; if too thin, rainbow colors show on the article and it must be dipped again.

Articles which cannot be hung up are generally dried in trays having bottoms made of wire cloth; a rather coarse mesh is used and the trays are stacked up over the source of heat, after the articles have ceased to drip. In this way great numbers of small articles may be handled in very little space, and may be left in the drying room long enough to become thoroughly hard, which is the chief point as regards durability of the lacquer.

Small establishments generally use a sheet iron drum or oven, which may be heated by gas or an oil stove to the degree required to bake the lacquer properly. To warm the articles they use a "hot plate," or an iron tray placed over a gas stove. Many small shops do their drying on wire trays resting on a steam coil, when

they can get steam the year round. The reader will perceive that the proper degree of heat is the main thing and that he can use his option as to applying it.

Brush lacquer is the same as dip lacquer, except that it is of thicker body, so as to spread well under the brush. A small portion at a time is turned out in a shallow pan or cup, and applied with fitch or camel hair brushes as rapidly and evenly as possible to the warmed article, which is then put in the drying oven and dried as for dip lacquer. Any little unevenness in the work will disappear in the oven, but considerable care and dexterity are needed to make a really nice job. For this reason most of the lacquering is done by girls, who do nothing else, and necessarily become experts at it. Nearly all special colors are applied with a brush and many of the most attractive finishes owe as much to the lacquer as to the dip, as the former in many cases lends transparent beauty to what would otherwise be a dull and prosaic color.

Great care must be taken to keep the lacquer away from all sources of moisture or grease, as either will cause white spots on the finished work. Lacquer will attract moisture from the air if allowed to stand in a damp room and much trouble has frequently been caused by neglect of this precaution.

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